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SEX-LIMITED CHARACTERS AND ALLOSOME-LINKED HEREDITY*.

JOHN H. SCHAFFNER
Department of Botany, Ohio State University

In developing a general theory of sex, it is necessary to consider all the fundamental phenomena of sexuality which occur in all the diverse types of plants and animals with their diverse types of life cycles, times of chromosome reduction, and diploid and haploid generations, otherwise a very incomplete or improper view of the subject will surely be obtained. Sexual dimorphisims, or sex limited characters are present from very low types of plants and animals and continue to the highest representatives of both kingdoms. The general nature of sex-limited characters differs in no wise in the higher forms from the lower except that the higher may have a much greater complexity of hereditary factors that may be influenced by the sexual state in their expression.

The presence of allosomes in a few plants and in apparently all of the higher animals complicates the study of sexuality and must be carefully considered, as well as the mode of transmission of the hereditary potentialities, if proper deductions are to be made as to the nature of sexuality in such forms. Heteromorphic allosome mates plainly have differences in hereditary factors and since these chromosomes have a peculiar and usually definite distribution in relation to the sex of the individual, they give rise to characteristic sex-limited sex-influenced, and sex-associated characters.

It is the intention to present in a very brief way an explanation of certain phenomena from the standpoint of the functional nature of sex in order to make clear to students who deal

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mainly with plant materials that there is nothing in the animal series that is incompatible with a consistent theory of sexuality as it is developed in plants and in lower animals. The writer has found that much confusion of mind does exist, obtained mainly from impossible hypothetical explanations of certain common types of animal heredity. These hypotheses have been highly elaborated and may appear quite plausible to one unacquainted with a great array of facts and phenomena of sexuality met with not only in plants but also in the lower animals, which flatly contradict the hypotheses and which their advocates have never attempted to consider.

Since heredity is a manifestation of the protoplast, a cytological interpretation must be developed as the basis of all speculations which go beyond observation. But since the hereditery character is the result of an expression through physiological activity, it follows that the dead cell inclusions and the physical state of the protoplasm itself at the time of expression may have a decided effect on the character developed. Now since sexuality is a condition or state of the individual, organ, cell, or chromosome, which may come and go and which can be reversed, it follows that the sexual characteristics of an individual may not always correspond to the actual allosome constitution, present. But whether allosomes are present or not, tissues or individuals genetically the same may show entirely different sexual characters in different parts of the body, depending on which sexual state is present during the development of the part. Such characters distinctive of male or female individuals or of parts of hermaphroditic individuals are sex-limited characters. The first step in developing an adequate conception of sex-limited characters is to study the dimorphisms in hermaphrodites and bisporangiate individuals and then proceed from the basis established to the dimorphisms of unisexual and monosporangiate individuals. Sex-limitation in monecious sporophytes may consist in the presence of a character or its complete or nearly complete suppression through one sexual state or the other, as for example the awn on the lemma of *Zizania aquatica* which is present on the carpellate spikelet but undeveloped on the staminate spikelet. In other cases there is merely a degree of difference of development or expression, as in *Cocos nucifera* in which the sepals of the staminate flowers are small and those of the carpellate flowers much larger; or as in the inflorescence of *Sicyos angulatus*

where the staminate inflorescence has a long peduncle and the carpellate inflorescence a short one. There are exactly similar differences in cases of unisexual and monosporangiate individuals. For example in Dorset sheep, the female has little horns and the male large ones, while in the Merino the males have horns and females have none. In *Carica papaya*, a diecious plant, the staminate corollas are sympetalous and the carpellate corollas are choripetalous. In the diecious *Acnida tamariscina*, the staminate flowers have a five-sepaled calyx, while the carpellate flowers have none.

Characters that are sex-limited may have their factors or potentialities either in the autosomes or in the allosomes. Recently it has become the vogue, in some quarters to rechristen the allosomes as "sex-chromosomes" and the characters, whether sex-limited or not, which have their potentialities in the allosomes as "sex-linked" characters. Now all chromosomes of sexual organisms are sexual chromosomes. There are no special factors or determiners for sex, nor sex-linked factors properly speaking. There is no "sex-linked heredity". Such terminology can only arise out of ignorance of sexuality as it is evolved in the organic kingdom and leads only to confusion and misunderstanding of things as they actually exist. Both terms are wrong because they tend to perpetuate an inadequate hypothesis of sexuality as well as a false notion as to the distribution of sexual characters. For example, when we say that ordinary Daltonism is "sex-linked" the term might naturally imply that the color-blindness was confined to one sex. But women are color-blind as well as men. Futhermore, when there is sex reversal, whether affecting the primary or secondary sexual state, the so-called "sex-chromosomes" do not at all indicate the sex of the cell or individual. The terms are improper also from the point of veiw of sexuality itself, since they imply that sex is a matter of Mendelian or chromosome heredity. The common occurrence of sex-reversal in both directions and the fact that commonly in plants the sex is not determined nor changed when the chromosomes, with their Mendelian heredity, are segregated show that fundamentally sex is primarily a thing apart from Mendelian heredity. Nor is sex usually determined in plants when chromosomes are aggregated in fertilization. In all vascular plants except the comparatively rare unisexual gametophytes of the homosporous pteridophytes and the diecious sporophytes of seed plants, both male and

female conditions arise from the same chromosome complex in the same individual, and futhermore, as stated, the sex can frequently be reversed in either direction in both haploid gametophytes and diploid sporophytes.

Sphaerocarpus seems to be the only known case in both the plant and animal kingdoms, where allosomes presumably might control or determine directly the primary sexual state and structures in a haploid organism, and here these states follow the presence of the secondary sexual states in the gametophytes. In animals as in the plants where such bodies are present, the segregated allosomes seem to have no influence whatever on the development of the primary sexual states or on the development of the primary sexual structures of the gametes. Then what is the basis for the assumption of a fundamental influence in the zygote?

From a correct, evolutionary point of view it is evident that the allosome condition is the result of sexuality rather than its cause. It is only in the most extreme type of sex-determination in the gametophyte, where the sex is determined in the spore, that a differential distribution of chromosomes could arise, which could influence functional states; and in the final development of dieciousness, there is again a condition established in which allosomes with differential heredities could be evolved and continued in a definite sex-association in the individual.

At most, allosomes might be the cause of the diecious conditions or of some unisexual individuals whether diploid or haploid; but this is only one of the special aspects of sexuality, not the important problem to be solved, either of primary sexual states and characters, or of secondary states and characters. It must be remembered that sexual dimorphism is just as wide-spread and prominent in the individual in species without evident allosomes, like the hemp for example as in species with allosomes (See Schaffner 19, 22, and McPhee 10.) But allosomes are not at all an explanation of unisexuality; for all of the 150,000 species of heterosporous plants have unisexual gametophytes, and in not a single one of these has the unisexual condition any relation to allosomes. The very nature of the life cycle makes such a relation impossible.

So far as we have present knowledge, we can have chromosome-linked heredity or factors and perhaps cytoplasm-linked and plastid-linked heredity. Chromosome heredity falls into

two categories, autosome-linked heredity and allosome-linked heredity, but the hereditary factors or potentialities of autosomes and allosomes are essentially the same in nature, since organisms with allosomes show nothing fundamentally different from those which have no such bodies.

Sex-limited characters are physiological as well as morphological. The instinctive characters peculiar to one sex or the other are readily reversible, as has been known for a long time, as well as the morphological characters. Now if our notions of Mendelian heredity are correct, all sex characters which are of a unitary nature must in the end be due to one or more hereditary factors. These factors, as understood at present, are presumably chromosome-linked; that is, they are properties of certain chromosomes or parts of chromosomes. For convenience we can assume that they are in the chromatin granules as Mottier (15) suggested in 1907.

As intimated before, the autosome-linked factors give rise to one type of sex-limited characters and the expression is the same whether it occurs in either hermaphroditic or bisporangiate individuals on the one hand, or in unisexual or monosporangiate individuals on the other. Whenever a given sexual state is present, the factors in the autosomes express a peculiar character or group of characters that we recognize as male or female as the case may be. The expression changes with the change of sexual state. This is evident both in monecious plants and in reversed diecious individuals.

Since the allosomes show a peculiar distribution in relation to the sex of the individual any factors they may have may show a peculiar association with one sex or the other, while characters which have their potentialities in the autosomes will show no special associative peculiarities in relation to either sex when Medelian segregation occurs. Any factors in the allosomes subject to sex-limitation can, of course, only show the characters where they are actually present in the proper sexual state. Such characters are sex-limited characters of allosome-linked herdity. Allosomes may have herdity not sex-limited the same as have the autosomes. Such heredity will show a peculiar distribution in relation to sex in reciprocal crosses.

The writer does not wish to discuss in all its details the probable cause for the definite distribution of allosomes in relation to male and female sex, but it can be definitely stated that this condition, whether ascribed to specific, differential

attraction or whether we assume that the allosomes are sex-producing through their influence on the functional activity of the cell, is not at all antagonistic to the physiological theory of sex. Because of the ease with which certain allosome-bearing plants and animals change their sexual states under certain conditions, the writer inclines strongly to the differential compatibility hypothesis at the present time. The assumption of a greater or less degree of specfic compatibility or incompatibility and of a consequent specific attraction and selective union of gametes with allosome differences together with a changing metabolic gradient modifying the primary sexual state of the eggs of heterogamous organisms brings the situation as presented by the allosome-bearing organisms into complete harmony with that found in hermaphrodites and bisporangiate sporophytes of the various types as well as with that found in those strongly dimorphic unisexual and diecious species, in which no allosomes are present. The nature of sex-determination in relation to allosome will be further discussed below in connection with the special problems of allosome heredity and sex-limited characters.

Since X and 2X are established symbols in an extensive botanical literature and are still almost universally used by botanists to designate the haploid and diploid complements of chromosomes, X and Y cannot properly be employed as symbols for allosomes without causing an endless amount of confusion in both morphology and genetics. In the present paper A and B will be used as symbols instead of the much used but confusing symbols "X" and "Y" and "W" and "Z". "A" represent the allosome which in diploid individuals is normally associated with either sex; "B" represents the allosome which in diploid individuals is normally associated with but one sex. Whenever we have the allosome formulæ ♀ AA and AB♂, or ♀ AB and AA ♂, or ♀ Ao and AA ♂ there is apparently indiscriminate migration of the A allosome to either sex, just as in the case of autosomes, but the B allosome under the normal conditions is associated with a single sex, either the male only or the female only.

Although there are many peculiar types of allosome constitution, the most common types of animals and plants in relation to the allosome condition are the seven presented below. A and B represent the allosomes, and X the haploid complement of autosomes or the chromosomes in general when no allosomes are present.

I. MAN, DROSOPHILA, etc. (See Painter (20) and Stevens (29).

♀ $\frac{AA}{XX}$, $\frac{AB}{XX}$ ♂. Diploid individuals.

Eggs = $\frac{A|}{X}$, $\frac{|A}{X}$. Determined as ♀ $\frac{A|}{X}$ and $\frac{|A}{X}$ ♂.

Sperms = $\frac{A|}{X}$, $\frac{|B}{X}$.

In some mammals decided reversals of secondary sexual characters have been observed.

II. ABRAXAS. (Probably). No cytological difference visible. (See Doncaster (4).

♀ $\frac{AB}{XX}$, $\frac{AA}{XX}$ ♂. Diploid individuals.

Eggs = $\frac{A|}{X}$, $\frac{|B}{X}$. Determined as ♂ $\frac{A|}{X}$ and $\frac{|B}{X}$ ♀.

Sperms = $\frac{A|}{X}$, $\frac{|A}{X}$.

In this allosome type remarkable sex-intergrades have been developed by crossing species. (See Goldschmidt (7).

III. CHICKEN. (See Guyer (9).

♀ $\frac{Ao}{XX}$, $\frac{AA}{XX}$ ♂. Diploid individuals. o = zero.

Eggs = $\frac{A|}{X}$, $\frac{|o}{X}$. Determined as ♂ $\frac{A|}{X}$ and $\frac{|o}{X}$ ♀.

Sperms = $\frac{A|}{X}$, $\frac{|A}{X}$.

Decided sex reversals observed; female individuals reversed to secondary male state and even to the normally functioning primary male state; males, so far, reversed to secondary female state only.

IV. SPHAEROCARPUS. (Plant). (See Allen (1).

Sporophyte = $\frac{AB}{XX}$ Neutral. Diploid individuals.

Spores = $\frac{A|}{X}$, $\frac{|B}{X}$. Determined as ♀ $\frac{A|}{X}$ and $\frac{|B}{X}$ ♂.

Gametophytes = ♀ $\frac{A|}{X}$, $\frac{|B}{X}$ ♂. Haploid individuals.

Gametes = ♀ $\frac{A|}{X}$, $\frac{|B}{X}$ ♂.

No sex reversal known.

V. EQUISETUM ARVENSE and OSTRICH-FERN. (See Wuist (32). No allosomes present.

Sporophyte = $\frac{o\,o}{XX}$ Neutral Diploid individuals.

Zero (o) = absence of allosome.

Spores = $\frac{o|}{X}$, $\frac{|o}{X}$. Determined as ♀ $\frac{o|}{X}$ and $\frac{|o}{X}$ ♂.

Gametophytes = ♀ $\frac{o|}{X}$, $\frac{|o}{X}$ ♂. Haploid individuals.

Gametes = ♀ $\frac{o|}{X}$, $\frac{|o}{X}$ ♂.

Complete primary and secondary sex reversal easily brought about; female to male and male to female. The male to female reversal much less frequent than the reciprocal reversal.

VI. CANNABIS SATIVA. (See McPhee (14). No allosomes present.

Sporophyte = ♁ $\frac{oo}{xx}$, $\frac{oo}{xx}$ ^{oo}. Diploid individuals strongly sexually dimorphic.

Spores = ♀ $\frac{o}{x}|$, $|\frac{o}{x}$ ♀. Megaspores with secondary sexual dimorphism

and ♂ $\frac{o}{x}|$, $|\frac{o}{x}$ ♂. Microsphores with secondary sexual dimorphism.

Gametophytes = ♀ $\frac{o}{x}|$, $|\frac{o}{x}$ ♀ and ♂ $\frac{o}{x}|$, $|\frac{o}{x}$ ♂. Haploid individuals very strongly sexually dimorphic.

Gametes = ♀ $\frac{o}{x}|$, $|\frac{o}{x}$ ♂. Primary sexual state.

Female gametes before or after fertilization = ♀ $\frac{o}{x}|$, $|\frac{o}{x}$ ♂.

Both partial and complete sex-reversal easily brought about, carpellate to staminate and staminate to carpellate.

VII. HUMULUS JAPONICUS. (See Winge (31).

Sporophytes = ♁ $\frac{AA}{xx}$, $\frac{AB}{xx}$ ^{oo}. Diploid individuals slightly sexually dimorphic, decidedly so as to the inflorescence.

Spores = ♀ $\frac{A}{x}|$, $|\frac{A}{x}$ ♀ and ♂ $\frac{A}{x}|$, $|\frac{B}{x}$ ♂.

Gametophytes = ♀ $\frac{A}{x}|$, $|\frac{A}{x}$ ♀ and ♂ $\frac{A}{x}|$, $|\frac{B}{x}$ ♂. Supposed allosomes have no influence on the sex of the gametophyte.

Gametes = ♀ $\frac{A}{x}|$, $|\frac{A}{x}$ ♀ and ♂ $\frac{A}{x}|$, $|\frac{B}{x}$ ♂. Primary sexual state.

Female gametes before or after fertilization are ♀ $\frac{A}{x}|$, $|\frac{A}{x}$ ♂.

Both partial and complete sex-reversal easily brought about, carpellate to staminate and staminate to carpellate.

On the basis of the cytological conditions and of the physiological theory of the nature of sex, the various possibilities of transmission and expression of the more common types of heredity in relation to sex are considered below. This is not to be regarded as an exhaustive analyis, however.

In relation to allosome-linked heredity and sex limitation we can have the following specfic conditions:

1. Only the females are affected both by a single dose and by a double dose. Various types of hologynic heredity.
2. Only the males are ever affected both by a single dose and by a double dose. The various types of holoandric heredity.

3. Only the females (unpaired allosome condition) are ever affected, the heredity needed for the effect coming from the male. Dia-andric heredity.
4. Only the males (unpaired allosome condition) are ever affected, the heredity needed for the effect coming from the female. Diagynic heredity.
5. Both males and females are affected by a single dose, the heredity coming from either parent as a carrier. Ordinary dominant heredity and criss-cross heredity of the allosome condition in the chicken.
6. The females (homomorphic allosomes) affected only by a double dose, the males (heteromorphic allosomes) affected by a single dose. Daltonism, etc.
7. The males (homomorphic allosomes affected only by a double dose, the females (heteromorphic allosomes) affected by a single dose. The opposite of Daltonism. It should be possible in the Abraxas and chicken types of allosome constitution.
8. The females (heteromorphic allosomes) not affected, the males (homomorphic allosomes) affected by a double dose only. One type of holoandric heredity.
9. The males (heteromophic allosomes) not affected, the females (homomorphic allosomes) affected by a double dose only. One type of hologynic heredity.

Since sex is developed in the cell or in the individual in various degrees of intensity and persistency, a low condition of maleness or femaleness may not inhibit or only partially inhibit in specific instances a given heredity so that exceptions to the statements may appear.

Now considering the various possibilities under each of the seven types of chromosome constitutions tabulated above, a definite program can be laid out by which any given case of herditary transmission and its sex-limitations can be studied and defined.

I. Human and Drosophila Type.

The type of chromosome constitution in which the female is homomorphic and the male heteromorphic for the allosomes "A" and "B", well established by cytological evidence (Painter 20, Stevens 29), may give rise to the following conditions, if A has a sex-influenced factor "*k*" and B has a sex-influenced factor "*l*."

1. A may have a factor *k* latent in the cell in the presence of the male state and in the presence of B.
2. A may have a factor *k* active in the cell in the presence of the male state and in the presence of B.

3. B may have a factor *l* latent in the cell in the presence of the male state and in the presence of A. The factor could only appear in case of sex reversal or abnormal allosome or chromosome associations.
4. B may have a factor *l* active in the cell in the presence of the male state and in the presence of A.
5. A may have a factor *k* latent in a single dose in the presence of the female state when associated with an allosome A without the factor.
6. A may have a factor *k* which is active even in a single dose in the presence of the female state when associated with an allosome A without the factor; and of course then also active in double dose.
7. A may have a factor *k* which is active only in a double dose in the presence of the female state.
8. A may have a factor *k* which is latent even in double dose in the presence of the female state.

Abnormal cases are produced by ordinary sex-reversal or by abnormal sex-determination because of the presence of supernumerary autosomes or allosomes in the cell, among which are the following:

9. B may have a factor 1 which may become active in the presence of a female state, although it shows no activity when the cell is in the normal male condition.
10. A alone, with a factor *k* might show activity of the factor when B is absent and in the presence of the male state.
11. A alone might have a factor *k* that is latent because of the absence of B and in the presence of the male state.

Ordinary Daltonism or red-green color blindness in man is apparently an example of cases "2","5", and "7". Records have been established of 7 color blind women who had between them 17 sons, all color blind.

A certain type of senile cataract as reported by Enriques (6) is apparently an example of cases "1", and "6".

Schofield's (27) pedigree of webbed toes in man is apparently an example of case "4," or of "2" and "8".

The terms diagynic, dia-andric, hologynic, and holoandric heredity as used by Enriques (6) would be convenient but they are apparently too limited in their scope for general use to cover all the different types of hereitary transmission and expression and will need to be extended, either by modifying phrases or otherwise, when all the modes of allosome-linked and autosome-linked heredity and the relation of the factors to sex-limitation are known.

In the human type of allosome constitution, namely ♀ AA, AB ♂ :

1. If B has a factor *l*, active in the presence of the male state, it can only be transmitted from male to male. If B has a factor *l*, latent in the male state, it will be transmitted directly from male to male but will never show except possibly in case of sex-reversal.
2. If A has a factor *k* which is active only in double doses in the presence of femaleness and not active in the presence of the male state, then none of the offspring of an affected female will have the character unless the unaffected male parent is a carrier in which case all the daughters will be affected and the sons will, of course, be carriers.
3. If A has a factor *k* active in the presence of the male state it can not be transmitted to the sons directly but only from a mother.
4. If A has a factor *k* active in the presence of the male state but only active in double dose in the presence of the female state then it can only be transmitted directly to the male from an affected or unaffected female, in the latter case only half the sons showing the character; but to produce an affected daughter the father must be affected and the mother either affected or a carrier, in the latter case half the daughters being affected. In specific instances affected male offspring may be appearing from the line and possibly affected females for a long time, until a female carring the factor is mated with an affected male.
5. If A has a factor *k* latent in the presence of the male state and B, but active in single dose in the presence of the female state associated with another A without the factor, and active also in double dose, then the character must be confined entirely to the female line and will appear in all the daughters if the mother has a double dose or if the father alone is a carrier. If the mother alone has the character and the heredity in single dose, half the daughters will be affected and half the sons will be carriers.
6. If A has a factor *k* which is latent even in double dose in the presence of the female state but active in the presence of the male condition, then the character will be confined to the male line but is transmitted to the sons only through the unaffected mother.

Any hypothesis as to which allosome has the heredity potentiality in any specific case can be tested out to a certain extent by breeding experiments, especially if sex reversal occurs sporadically or can be produced experimentally.

In man and Drosophila, etc. the allosomes are homomorphic in the female and heteromorphic in the male according to the scheme of A and B as outlined above. But in certain animals like Abraxas apparently, the male has the homomorphic set and the female the heteromorphic. According to Guyer's (8 and 9) cytological studies, the male somatic cells of the common chicken show two allosomes while the female somatic cells show only one of these bodies. In this case then, as indicated the allosomes are all of the type A and the female

contains an unpaired A. In spermatogensis the two allosomes seem to pair and pass undivided to one pole, which would thus result in two spermatozoa each with an allosome and two without allosomes. The eggs presumably are formed half with an allosome and half without. Now to obtain the proper somatic condition, three possible things may happen: 1st., the spermatozoa without allosomes may not develop properly or, if they develop, fail to develop the primary sexual state completely; 2nd., the sperms may all develop properly but the eggs lacking the allosome may fail of normal development; or 3rd., all the eggs and sperms may develop properly but there is a lack of specific compatibility or an indifference between the eggs and spermatozoa without allosomes, or if these can conjugate the resulting zygote may be unable to develop. It is supposed, because of the results of the measurements of the spermatozoa, that the first assumption is the most probable.

We can assume that in the higher plants and the higher animals also, if the sexual state is determined in the gametes it is always determined in the egg, namely the sex which is continued in the developing individual; for apparently the sperm is too extremely differentiated into a male cell to pass over into the female state without passing through a seemingly impossible de-differentiation. Only in the very lowest sexual plants, like Spirogyra, for example, is it possible that a male gamete can pass over into the female state and this is actually known to occur occasionally. On the other hand it is well known that in the higher plants even a sister cell of the egg may pass to the minus or male state and conjugate with it. Occasionally sperms of some of the higher green algae have evolved to the condition in which they may pass back to a vegetative development as in certain species of Oedogonium, but in such cases a dwarf male is always the result.

When the eggs are homomorphic and the sperms heteromorphic, with AA ♀ and AB ♂ allosome sets, as in man, we can make three hypotheses as to sex-determination:

1. The haploid eggs having the same heredity and the same chromosome complement, the sex is determined by some physiological balance the same as in all cases of sex-determination in heterosporous, bisporangiate, diploid sporophytes; in haploid, hermaphroditic gametophytes in diploid hermaphroditic gametophytes; and in diploid, hermaphroditic animals; as well as in all cases of sex-reversal in diploid, monosporangiate sporophytes; in haploid, unisexual gametophytes; or in diploid unisexual animals or plants, whether allosomes are present in their cells or not.

Following this determination of the physiological gradient in the direction of one sexual state or the other there is a differential specific attraction with the more compatible kind of sperm, the egg determined toward maleness attracting the sperm with the allosome B, with its peculiar hereditary constitution, and the egg determined toward femaleness attracting the sperm with the allosome A. In this case the sex would actually be determined while fertilization is taking place, but it may also be normally completely determined before coming in contact with the sperm, but this does not mean that the sexual state is completely developed any more than that a new born child has its cells in a completely sexual, male or female state.

Not only do we know of the compatibility and incompatibility of the gametes of the same and of dissimilar species but in the synapsis of the chromosomes there is evident a very decided compatibility of synaptic mates and apparently a very decided incompatibility of chromosomes which are not mates. Moreover the differential parasitic growths of pollentubes is well known, which results in decidedly disturbed Mendelian ratios.

2. All the eggs may be in the same physiological condition at the time of fertilization, and attraction and union may take place purely by the law of chance and after fertilization the presence of the given type of allosome will produce a metabolic level that will throw the fertilized egg invariably toward the one sex, that with the allosomes AA toward femaleness and that with the allosomes AB toward maleness. There is nothing incompatible in this hypothesis with the physiological theory of sex. The sex is determined in exactly the same way as when determined or reversed in the vegetative tissues of the body, the special allosome merely giving the proper physiological state under the normal conditions. The allosomes are *merely sex-producing* having a direct effect on the physiology of the protoplast. The main difficulty with the hypothesis is that if the allosomes are thus sex-producing, the sexual state should remain unchanged so long as the bodies are present, which is plainly not the case in the great number of examples in which both secondary and primary sexual states are reversed in the individual. As stated, we have no objection to any one holding this second hypothesis provided he can give a convincing explanation as to why allosomes are specific and invariable sex-producers immediately after fertilization, before any specific sex is established, but cannot hold the sex after the soma is developed and a given sexual state thoroughly established.

3. There is not only random mating but the allosomes are Mendelian sex determiners in the same way as the autosomes determine the ordinary Mendelian characters, the female being homozygous and the male heterozygous for sex or vice versa. The allosomes are real "sex chromosomes". This third hypothesis is, however, so contradictory to the mass of known facts in relation to sexuality, so monstrous a misfit as an explanation of maleness and femaleness as it appeared and evolved in both the plant and animal kingdoms, that the wonder is that it could ever have been taken seriously as a scientific explanation of the facts of sexuality that have so far been amassed.

When the eggs have similar allosomes, therefore, the sex, either male or female, is determined by a physiological balance the same as in organisms without allosomes as for example in monecious species and in various diecious plants like the hemp where allosomes are apparently lacking. Now this balance may be conceived of as a certain point in the metabolic gradient of the cell or tissue involved. If the metabolism falls to one side the condition leads on to femaleness, if to the other to maleness for the given species. In some diecious plants, as in Arisaema triphyllum, the sexual state may not be developed in the egg at all but at a later stage and the physiological balance appears to be such that probably the sex is at first always thrown to maleness, although this is not yet entirely certain. The writer found a strong tendency toward maleness in young offshoots, no difference whether the parent corm was for the time being producing staminate or carpellate shoots.

In cases where the eggs have the heteromorphic allosomes, or where part of the eggs have an allosome and part have none we may consider that the sexual states arise in the same fundamental way as in other cases, but that the egg without the allosome or with the B type of allosome is thrown to femaleness while the A-containing egg is thrown to maleness. In this case no selective mating could arise and no incompatibility in relation to allosomes, unless the given egg under certain conditions, produced no reaction whatever in the sperms in which case individuals of only one sex would be produced at the time, for under the allosome conditions considered the sperms would all be alike. If any one objects with the proposition that the egg with the allosome should be thrown to femaleness and the one without to maleness, then we can only direct them to the condition in the flowers of the Anthophyta where the determinate floral axis always passes to the male state first and then to the female state near the end of the determinate growth; and also to a certain type of monecious inflorescence, the axis of which always develops the female state first with carpellate flowers and later the male state with staminate flowers, toward the end of the determinate growth when theoretically we might expect the opposite to take place. But as intimated above, in chickens the sperms without allosomes may develop and the eggs without allosomes may fail to function, in which case all the eggs would have the same type of allosome and a balance could be established through a physiological gradient.

In birds and similar cases therefore, the sex is determined in the egg apparently according to the allosome constitution, the allosome determining the physiological state. The egg without the allosome is determined as female that with the allosome as male. This is contrary to the usual assumption that the greater quantity of chromatin determines femaleness. But on the physiological basis of sex determination, the allosome associated with the male condition either single, as in the unfertilized egg, or double, as in the individual, may have factors which depress the nutrient level, so the absence of the allosome with the absence of these physiological factors would tend to produce femaleness. After fertilization the male has two of the A. allosomes and the female one A. It is, therefore, only a matter of degree or intensity of influence and we would then expect that the female could be changed to a male or the male to a female condition without great difficulty as is actually done by experiment at the present time.

Although the quantitative theory of sex, as developed by Goldschmidt, comes much nearer to the facts of sex determination and expression than the homozygous-heterozygous Mendelian hypothesis, which has up to the present been so blindly and enthusiastically accepted; it will be evident to any one familiar with the fact of experimentally induced sex reversals and re-reversals in unisexual individuals, as accomplished by the writer, as well as from a host of other phenomena, that any balance of genes imagined cannot be an explanation of sex determination and sexual dimorphism, since the change from one sex condition to the other and then back again is brought about during vegetative growth by ecological means, without disturbing, by aggregation or segregation, any balance of genes that might be present.

II. Abraxas Type.

The allosome formula is apparently ♀ AB, AA ♂. In general the conditions of activity and latency in relation to sex will be just the opposite from those in the human type.

1. A may have a factor *k* latent in the cells in the presence of the female state and in the presence of B.
2. A may have a factor *k* active in the presence of the female state and in the presence of B.

3. B may have a factor *l* latent in the cell in the presence of the female state and in the presence of A. This could never appear in character except in cases of sex reversal.
4. B may have a factor *l* active in the cell in the presence of the female state and in the presence of A.
5. A may have a factor *k* latent in a single dose in the presence of the male state when associated with an allosome A without the factor.
6. A may have a factor *k* which is active even in single dose in the presence of the male state when associated with an allosome A without the factor, and of course then also active in double dose.
7. A may have a factor *k* which is active only in a double dose in the presence of the male state.
8. A may have a factor *k* which is latent even in double dose in the presence of the male state.

Irregularities in allosome and chromosome distributions and sex reversals may, of course, occur as in the ♀ AA, AB ♂ type and produce unusual results in relation to sex limitation.

In Abraxas the grossulariata color as contrasted with the lacticolor is evidently a case of "2" and "6". The characters are not at all sex-limited or "sex-linked" but appear in either sex according to the ordinary Mendelian expectation limited, however, by the particular mode of migration of the allosomes. They are characters expressed by allosome-linked factors.

In the Abraxas type the heredity in relation to the allosomes may be transmitted as follows:

1. If B has a factor *l* active in the presence of the female state, it can only be transmitted from female to female. If B has a factor *l* latent in the female state, it could never show normally except in case of sex reversal.
2. If A has a factor *k* which is active only in double dose in the presence of maleness and not active in the presence of the female state then none of the offspring of an affected male will have the character unless the unaffected female parent has the factor also in which case the male offspring will be affected and the female offspring will become carriers.
3. If A has a factor *k* active in the presence of the female state and in the presence of B it cannot be transmitted to the daughters directly but only from a father.
4. If A has a factor *k* active in the presence of the female state but only active in double dose in the presence of maleness then it can only be transmitted directly to the female from an affected or unaffected male.
5. If A has a factor *k* latent in the presence of the female state and of B but active in single dose in the presence of the male state and another A without the factor and active also in double dose in the presence of the male state, the character will be confined entirely to the male line.

6. If A has a factor *k* which is latent even in double dose in the presence of the male state but active in the presence of the female state then the character will be confined to the female line but is transmitted to the female offspring only through the unaffected male parents.

III. Chicken Type.

The allosome formula is apparently ♀ Ao, AA ♂, the cells of the normal female having a single allosome.

1. A may have a factor *k* latent in the cell in single dose in the presence of the male state.
2. A may have a factor *k* active in the cell in single dose in the presence of the male state and, of course, also in double dose.
3. A may have a factor *k* active only in double dose in the presence of the male state.
4. A may have a factor *k* latent even in double dose in the presence of the male state.
5. A may have a factor *k* latent in single dose in the presence of the female state.
6. A may have a factor *k* active in single dose in the presence of the female state.

When sex-reversal takes place, which is comparatively frequent in the case of the hen, latent factors in the allosome as well as sex-limited factors in the autosomes may become active. Chickens apparently furnish favorable material for the study of allosome-linked and sex-limited heredity.

Any factor in A active in the female state can be derived only from the male parent directly, so until the normal heredity is established in a cross, great care must be taken else a desirable factor may be lost. Taking into account the allosome formula, the migration of the allosomes and the condition of any factors which the allosomes contain the hereditary transmission can easily be worked out.

Taking the well-known case of the golden Sebright and silver Sebright bantam chickens and assuming again that the eggs are heteromorphic and the sperms homomorphic in respect to allosomes because of the failure of the allosome-lacking spermatids to develop properly, then we can explain the breeding results (see Punnett 21) as follows:

Suppose that "silver" is dominant and "golden" recessive and that these factors are in the allosomes A, and suppose that the eggs with allosome A are determined as males and the eggs without allosome A are determined as females. Then crossing

golden Sebright ♀ with silver Sebright ♂ will give only silver females and only silver males; for both types of eggs will get an allosome A containing the factor S.

Silver Sebright ♀ crossed with golden Sebright ♂ will give golden females and silver males, because the females will get an allosome with factor g (golden) and have no silver while the males would have an allosome with golden and also one with the dominant silver.

The F2 from the F1 of the first cross will give both silver and golden females but only silver males; for the eggs will be half without and half with the A allosome containing the factor for silver and the sperms will be half with allosome A containing the factor for golden and half with allosome A containing the factor for silver which will thus always give a male with at least one dose of silver.

The F2 from the F1 of the second cross will give both silver and golden females and both silver and golden males; for the eggs will be without the allosome or else have the allosome A containing the factor for golden and the sperms will have either the allosome A with the factor for golden or the allosome A with the factor for the dominant silver. So the allosome-lacking egg can receive either allosome A (g) or allosome A (s) and the other type of egg will have only the allosome A (g) which on conjugating with one or the other type of sperms will produce a zygote homozygous for golden and the other heterozygous for the dominant silver.

The characters are, therefore, not at all sex-limited nor "sex-linked" but are in plain language non-sex-limited characters whose factors are allosome-linked.

The familar example of the cross between non-barred Cornish Indian Game chickens and Barred Plymouth Rocks is of the same nature as well as various other sets of allelomorphic characters whose potentialities presumably are in the allosome A.

IV. Sphaerocarpus Type.

Since the sporophyte is homosporous no sexual dimorphism is possible in it but hereditary factors in allosome A or in allosome B may be active and if this is the case characteristic hereditary transmissions would appear. The gametophytes having the haploid complement of chromosomes and each kind of allosome being constantly associated with one sex, any

allosome-linked factors could only produce characters in the one sex unless sex-reversal takes place. Any sex-limited character or any character not sex-limited whose factors are in the allosomes would show a 1 to 1 ratio. Any factor in allosome A would give a character constantly associated with femaleness and any factor in allosome B would give a character constantly associated with maleness. In case of a heterozygous condition of a sex-limited factor in the autosome any gametophytic character will appear in half the males or in half the females as the case may be.

V. Equisetum arvense Type.

The sporophyte is homosporous and can normally have no sexual dimorphism. There are no allosomes but the haploid gametophytes are determined in the spores or in the early stages of germination as female and male individuals with ordinary sex-limited characters. Both gametophytes can be reversed and the newly developed parts will then show the opposite sex-limitation. Factors which are heterozygous in the sporophyte will show equal segregation and will show equal ratios in the two sexes; while any such heterozygous factors that give rise to sex-limited characters in the gametophytes will also show in half the individuals of the sex involved.

VI. Cannabis sativa Type.

No allosomes being present in the diecious hemp, the sex is determined in the eggs of like hereditary constitution either before or after fertilization and the potentialities of the sex-limited sporophytic characters, which are numberous, are all in ordinary chromosomes. In case of sex-reversal all the sex-limited characters of the opposite sex that can be developed in the reversed parts appear. No heredity or condition of any kind is known to influence the sex of the gametophytes although the sporocytes may undergo sex-reversal. The haploid complement of chromosomes will show male sex-limited characters in the pollen grains no difference what the hereditary complex may be, after male determination in the sporophyte; and the same complement of chromosomes will show female sex-limited characters in the female gametophytes after female determination in the sporophyte. The sex is not affected by the reduction division. Whether any specfic factors give rise

to sex-limited characters in both gametophyte and sporophyte is not known. Since sex-reversal is easily accomplished, characters latent and normally never appearing in the sex present will show in the reversed branches and thus reveal the presence of heredity in the given individual which could otherwise only be inferred.

VII. Humulus Type.

Any allosome-linked herdity and sex-limitation in general will be expressed in the same way in the sporophyte as in Man and Drosophila. The sex of the gametophytes has no relation to the allosome distribution but follows that which was present in the flowers which produced the spores from which the gametophytes originate. Abundant sex reversal is produced in the sporophyte, the male to the female and the female to the male, by means of a short daily illumination period. The carpellate plant with the homomorphic set of allosomes possesses all the factors or potentialities of both sexes the same as the staminate plant with the heteromorphic set of allosomes. The homozyous-heterozygous sex formula is thus a figment of the imagination.

The Five General Types of Hereditary Expression.

The five general types of hereditary expression as influenced either by primary or secondary sexual states may then be summarized as follows:

1. The peculiarity of inheritance produced by dominance and recessiveness through which an individual shows characters transmitted directly from one parent only, which characters have no relation to the special sex of the individual or any part of the individual under the influence of a sexual state, their factors being influenced only by the ordinary physiological conditions or gradients which cause them to be active or latent for the time being. These are the ordinary Mendelian heredities often observed to be handed down from father to daughter or from mother to son, or vice versa in either case. The factors are autosome-linked or, in case there are no allosomes, merely chromosome-linked, and the characters are not sex-limited.

2. Sex-limited or sex-influenced heredity, the factors being autosome-linked and expressing characters either through direct influence or through latency or activity brought about by the presence of one sexual state or the other. These are the ordinary sex-limited characters producing sexual dimorphism either between entire individuals or different parts or cells of the same individual.

3. Hereditary characters whose factors are in the allosomes, on account of which they receive a distinctive distribution in transmission not sex-limited or sex-influenced in nature however.

4. Hereditary characters which have their factors in the allosomes and are sex-limited in single dose through the action of one sexual state or the other.

5. Hereditary characters which have their factors in the allosomes and which are sex-limited in double dose through the influence of one sexual state or the other.

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THE ALIMENTARY CANAL OF THE MEXICAN BEAN BEETLE.

SAMUEL F. POTTS
Gipsy Moth Laboratory, Melrose Highlands, Mass.

INTRODUCTION.

The Mexican Bean Beetle, *Epilachna corrupta* Muls., is entirely a plant feeder, living usually on the leaves of garden and field beans. Its feeding habit differs in this respect from most other coccinellids, which (except for a few species), are predaceous on other insects.

Data concerning the economic importance, distribution, life history, habits, and control of the Mexican bean beetle have been published elsewhere by a number of writers, but no information concerning the internal anatomy was available. This work was undertaken because of the author's desire to become better acquainted with the internal structure.

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The Gross Anatomy.

The alimentary canal is shown in Figure 1. It is a more or less simple tube running from the mouth to the anus. The canal has three, well-defined, primary divisions. These are the fore-intestine, mid-intestine and hind-intestine. The canal of the beetle is three times the length of the beetle, while the canal of the larva is nearly twice the length of the larva.

The fore-intestine is very short, extending back only as far as the first thoracic segment. It consists of a short pharynx, a short oesophagus, and a short, somewhat thin-walled crop. The oesophagus is slightly greater in diameter than the pharynx.

The mid-intestine or ventriculus is divided into what is known as the first and second divisions of the ventriculus. The first division runs from the first segment to the fifth segment in the form of a nearly straight tube of uniform diameter. At the fifth segment there is a slight constriction. From here the second division begins in the form of a tube one-third less in diameter than the first division, but twice the length of the first division. During its course it twice coils back on itself.

The hind-intestine, which is composed of three regions, starts at about the beginning of the eighth segment where it joins the mid-intestine slightly at an angle. The six malpighian vessels arise near

the point of union, and after a more or less lengthy course through the body cavity, they enter the large intestine at a point just behind where the ileum (first division) joins the colon (second division). The ileum is small, short and somewhat twisted.

The ileum attaches to the colon on the right side of the body at the beginning of the ninth segment. From this point the colon gradually enlarges as it bends back towards the meson, dorsad of the ileum. The diameter of the colon (including the peritoneal sheath that surrounds it) is nearly twice the diameter of the ileum and almost exactly twice the diameter of the rectum. The colon passes directly into the rectum (third division), which is only one short segment in length. The rectum is surrounded by well developed circular muscles, inside of which are eight epithelial folds bordered with intima which nearly fills the lumen. The excrement is always fluid-like and a large open passage would probably not be necessary.

Larva and Adult.

The histological nature of the digestive tract of the larva is very similar to that of the adult. The discussion given in this treatise is concerned with the adult. However, mention is made of the larva in places where the difference in the two is most noticeable.

The Histology of the Alimentary Canal.

THE FORE-INTESTINE.

Proportionately the pharynx is very short. The histological nature of the pharynx and oesophagus is almost identical in regards to the type of intima and epithelium. The epithelium is more simple and is not thrown into folds as is the case with the oesophagus. Epithelium cells of this region are slightly smaller and more irregular than in the oesophagus. The diameter of the oesophagus is only slightly greater than that of the pharynx while the diameter of the mid-gut is about three times as great as the diameter of the oesophagus. See Figure 5.

Intima of the oesophagus is only moderately well developed, and seems to be thrown into a series of longitudinal folds, usually four in number. The primary intima is very thin and stains slightly with eosin. The teeth are backward pointed and rather strong at the anterior end of this region, but disappear at the posterior end, and are here replaced by rather blunt projections and depressions in the folds of intima.

The epithelial cells of the oesophagus are small and irregular, and the cell divisions are not always clear. The nuclei stain rather dark. The cytoplasm is non-vascular, non-granular, and homogenous. A cross section through the oesophagus is shown in Figure 3.

The basement membrane is not clearly distinguishable in all the sections.

About fifteen longitudinal muscle fibers occur between the circular muscle layer and the basement membrane. They are inserted in the intima near the posterior end of the pharynx. From here they continue through the fore-intestine, the mid-intestine, and a part of the hind-intestine.

The longitudinal muscles of the fore-gut and circular muscles of the mid-gut lie snugly against the basement membrane, and are not very strongly developed except at the oesophageal valve.

The crop is not so well developed in *Epilachna corrupta*. See Figure 5, C.

The oesophageal valve, as in similar cases among insects, is a large fold of the fore-intestine, projecting into the mid-intestine, nearly closing the passage between them. Unlike the alder flea beetle (Woods, 1918) in this respect, the oesophageal valve of the bean beetle is rather large, with bulb-like folds, which are well developed. See Figures 4 and 5.

The intima is very thick towards the oesophagus, but becomes gradually thinner as one passes towards the mid-intestine, finally disappearing at a point immediately behind the top of the two folds which form the valve. The intima (chitin) on the folds has a somewhat bluntly-jagged or dull, toothed appearance.

The peritrophic membrane is secreted by the digestive epithelium on the posterior side of the oesophagael valve. This is a delicate structureless membrane, which is found in the lumen of the mid-intestine and the hind-intestine, lying between the food and the delicate epithelium. It protects the latter from injury from sharp food particles. Digestive juices secreted behind this membrane probably pass through it by osmosis.

A striated border in this region of the mid-intestine is seldom visible, and is never well developed.

The epithelial cells of the fore-gut in the anterior face of the oesophageal valve become cuboidal, then slightly more columnar, narrower, more elongate, and gradually change to the type more characteristic of the mid-gut.

On the posterior face of the oesophageal valve the cells are very long, narrow and crowded. They have small, oval nuclei which contain small, usually well separated chromatin granules. The layer of cells are arranged in such a way that they appear as being in more than one irregular layer, closely wedged together. The epithelium of the two oesophageal valve folds, particularly on the posterior side, stains rather dark. On the posterior face of the valve folds the cytoplasm granules are fine and dense.

The basement membrane is continuous from the fore-intestine to the mid-intestine.

The longitudinal muscle fibres are continuous from the fore-gut to the mid-gut. They are internal in the fore-gut and external in the mid-gut. The fibres evidently divide into two or three upon leaving the oesophageal valve since from a dozen to about fifteen medium-large fibres are found in the fore-gut, while from thirty-six to forty small fibres are observed in sections made through the mid-gut. All the fibres of the fore-intestine are larger than those of the mid-intestine.

THE MID-INTESTINE.

First Division of the Ventriculus.

A striated border is not clearly distinguishable in the anterior region of this division in *Epilachna corrupta*, but a rather thin striated

border is found towards the posterior end of this region. This condition is possibly due to the glandular nature of the cells in this vicinity and will be discussed later. The striæ are close together and not always clearly separated from the cytoplasm anteriorly.

The epithelium is of the columnar type and the cells are well defined. The cells of the anterior part of this region are long and medium wide, but may vary some in the same insect. In the anterior part of this same region, immediately behind the oesophageal valve, are found six to eight deep pits or annular folds, and it is from these pits that most of the secretion in this region comes. These annular pits or pouches may extend entirely around the intestine, and are found throughout the first one-third of the first division of the ventriculus, and can be seen in dissection. The epithelium of the posterior end of this division is not replaced by typical nests, but instead has embryonic cells scattered along the basement membrane at the base of the epithelium. The same conditions occurs in the larva. The nuclei are rather large, round, and usually medium in position except when the cell contents are being discharged. The cells are about four to five times as high as they are wide, depending upon their physiological condition. Cells at the anterior end of this division are much higher than those near the posterior end. In the resting state the cytoplasm becomes charged with vacuoles, which pass to the outer margin of the cells. A very thin basement membrane is present. See Figures 5 and 6.

Small, thin, striated circular muscle fibres surround the mid-intestine. The fibres are branched. They usually appear as one delicate muscular layer. This layer is outside the longitudinal muscles in the fore-gut and inside the longitudunal muscles in the mid-gut. Approximately thirty-six longitudinal branched muscle fibres lie outside the circular muscle layer. They become smaller towards the posterior end of the mid-gut.

The Second Division of the Ventriculus.

The striated border is not very well developed in this region. It shows more clearly at the posterior end of the first division of the ventriculus, but apparently it continues throughout the mid-gut with different degrees of development. The striæ do not seem to be clearly separated from the cytoplasm in this portion of the ventriculus. See Figures 9 and 10.

The epithelial cells are much longer and narrower than those of the first region. Often they nearly fill the lumen. They are not equal and straight as in the case with the posterior end of the first mid-gut division. The free ends of these cells are irregular to oval in shape. The secretions are more active here than in the preceding region. The cytoplasmic balls are very granular and stain a light pink with eosin. See Figure 8.

Discharged cells are replaced from nidi or nests of embryonic cells which lie on the basement membrane. The number of nests in a single section is from fifteen to twenty-five. Usually each nest contains from three to twelve nuclei. Usually these nidi are inside the circular muscles. However, some sections indicate that under certain conditions some of the nests lie outside the muscle layer.

Immediately preceding the transition to the hind intestine, the cells of the mid-intestine become smaller, more numerous and irregular. Small nests or nidi also become more prevalent. At the extreme end of the mid-intestine the cells lose their columnar structure, the cell divisions become very indistinct, and the replacement cells are close together and abundant. See Figures 12 and 13.

The basement membrane is of the same nature as in the former division.

Both circular muscle fibers and longitudinal fibers are of the same nature as in the preceding region.

THE HIND-INTESTINE.

No typical pyloric valve occurs in the gut of *Epilachna corrupta*. However, immediately behind the malpighian vessels the lumen of the ileum is very small, the intima smooth, and the epithelium nearly equal and straight, instead of being irregular or thrown into folds. Epithelial cells at this point are small and cubical with indistinct walls. The nuclei stain very distinctly. There are several compact, thick, interlacing circular muscle layers surrounding and fitting closely against the basement membrane, around the entire circumference of the intestine. Figures 11 and 14 show this condition.

The Proximal Portion of the Ileum.

The striated border of the mid-intestine stops entirely with the end of the mid-intestinal epithelium, and is here replaced by a layer of intima. Immediately behind the pyloric valve (Figure 15) there occurs a very thin primary layer of fine hair-like or cillia-like intima. The secondary intima is also thin but is solid and much thicker than the primary intima.

The epithelial cells of the hind-gut are at first narrow, but become wider and higher, and shortly merge into an epithelium typical of the middle portion of the ileum. The cytoplasm is slightly vascular, very fibrillar, non-vesicular, and homogenous. The epithelium is thrown into six large wavy folds, and is composed of slightly triangular to oblong cells, which are higher than they are wide. They are smaller than those of the distal ileum and do not have clearly distinguishable cell walls. The nuclei are round, chromatic, and full of densely packed granules.

The proximal portion of the ileum discussed here is very short and extends not more than a hundred micra caudad of the pyloric valve. See Figure 15.

The basement membrane is thin but is always present, it is continuous from one region to another, and clearly defined.

There are about fifteen to twenty longitudinal muscles fibers, which lie among connective tissue between the basement membrane and the circular muscles. Posteriorly they are probably inserted on the intima towards the distal portion of the ileum. There are usually three layers of circular muscle fibers which lie outside the longitudinal fibers. These fibers are well developed and about twice as thick as the mid-intestinal fibers.

The Distal Portion of the Ileum.

In the distal portion of the ileum all layers present are continuous with those of the proximal ileum.

A very narrow, irregular, tooth-like intima borders the epithelium. This intima is very thin and only appears as one (or primary intima). It becomes gradually thinner throughout this region.

The epithelium of this region is composed of medium-sized, irregularly cuboidal cells, whose cell walls are very distinct. The nuclei are medium large and may be round or oval in outline. They contain large, distinct, chromatic granules, especially in the center. The epithelium is often thrown into acute folds, but this varies in the different specimens. The folds are typically six in number. A very thin clearly distinguishable basement membrane is present. See Figure 16.

The longitudinal muscle fibers are continuous anteriorly with those of the distal-mid-intestine and end a little before reaching this region. They begin at the anterior end of the pharynx, are internal in the fore-gut, external in the mid-gut, and internal in the hind-gut (ileum). They are internal in the proximal region and end before reaching the distal end of the ileum. Circular muscle fibers are well developed, and as elsewhere, are striated. They are continuous anteriorly with those of the proximal section of the ileum, and posteriorly with those of the colon.

The Colon.

At the transition point or union the canal bends caudad but at this point there is practically no difference between the epithelium of the ileum as compared with that of the colon. The intima, basement membrane, and circualr muscles are continuous, while the longitudinal muscles of the ileum disappear entirely.

The intima is slightly thicker here than it was in the region just discussed, and a primary and secondary intima can be distinguished. In nearly all of the cases where the intima of the hind-gut is discussed by writers working on other Coleoptera, the intima is described by them as thicker than is in the case with the Mexican Bean Beetle. In this insect the primary intima appears only as a thin line. The secondary intima is clear and does not stain with eosin or with Delafield's haematoxylin.

In following the course of the colon towards the rectum the epithelial cells gradually become flatter and flatter. This change begins with the association of the malpighian vessels with the walls of the intestine. The epithelial cells of the distal portion of the colon are about one-third as high as those of the ileum. and are not quite as wide. The cytoplasm is of the same structure throughout, resembling very closely that of the preceding region. The nuclei are oval, and about the same size as those of the ileum, but the chromatic granules are slightly larger and fewer in number. Some of the cell divisions are clear, while some are not. Probably this is due to fixation. The epithelium is usually thrown into six acute folds which project into the lumen. See Figure 17. The basement membrane is always very thin and is not always distinct.

The circular layer of muscle fibers of the pyloric valve, ileum, and anterior part of the colon are well developed, but the fibers grow weaker and weaker as one traces them towards the rectum. They do not disappear, however, until the end of this region is reached. They are continuous with the circular muscles of the preceding region, where the most posterior muscle is inserted in the intima of the colon.

The Malpighian Vessels.

The malpighian vessels of the Mexican bean beetle are six in number, and constitute a single series, arising stysematically like six spokes on an axle. They begin at the junction of the mid-gut and the hind-gut and go anteriorly through the vicinity of the second division of the ventriculus (where they are very much coiled), and then closely appress the walls of the first division of the ventriculus as far as the crop (which is located in the prothorax). From this point they double back on themselves, and pass through the body cavity in close proximity to the intestine as far caudad as the rectum. At this point they again turn back on themselves until they reach the junction of the ileum and the colon, where three vessels enter the colon on each side very close together. They enter as six vessels, then divide, and re-divide, finally ramifying at the posterior end of the colon. A cross section made through the anterior end of the colon shows six small, circular vessels, while sections made through the posterior end of the colon may show as many as sixteen large irregularly shaped vessels.

The malpighian vessels are slightly larger along the vicinity of the ventriculus, but grow rather small a short distance before they enter the colon, and remain in this condition for a short distance after entering, then enlarge again towards the posterior end of this region. The vessels are of a thin, opaque-white color. See Figure 19.

The malpighian vessels in the body cavity are elliptical to circular in shape. They are covered interiorly by a lightly staining striated border. The striæ are pointed at the free ends, but wider at their bases. The cytoplasm stains a violet pink with eosin, is very granular, and presents a fibrillar aspect. The nucleus, which is proportionately large, varies in shape from elliptical to round, and is typically basal to central in position. The chromatic granules are large and usually well separated. There are four cells in a typical cross section. The malpighian cells of the free tubules have a distinct and well-developed basement membrane. There is no indication of a thin, delicate, irregular, lightly straining fibrillar area just inside the basement membrane as is the case with the cells of the distal portion of the tubules. A malpighian vessel, greatly enlarged, is shown in Figure 20.

The malpighian vessels are closely associated with the circular muscle layer of the colon. Their peritoneal sheaths grow out and join, so that a continuous nucleated peritoneal sheath is formed, which completely surrounds the colon enclosing the malpighian vessels. The vessels do not extend along the wall of the rectum, but instead they terminate blindly at the extreme posterior end of the large intestine. See Figure 17.

The Rectum.

The transition between the colon and the rectum is the most abrupt in the whole course of the alimentary canal. New circular muscles suddenly appear and the malpighian vessels and nucleated peritoneal sheath end abruptly. The epithelial cells of the colon become flatter and flatter, and the cell boundaries more and more distinct near the rectum; but this type changes very quickly to the glandular eosinophile cells, characteristic of the rectum. The rectum is very short and is only one-half the diameter of the colon.

There are at first more or less small, smooth, wavy folds in the intima and epithelium, but as one proceeds caudad these folds become more and more pronounced, and more tooth-like in shape, while the lumen becomes smaller. Probably the typical number of folds is six but as they are very irregular the number is often eight. The intima of this region is thicker, more jagged-like and more irregular than that of the colon. As expected, the primary and secondary intima are continuous with the primary and secondary cuticle of the body wall.

The cells of the epithelium are about one-half the size of those in the preceding region, but the cell divisions are not always clear. The epithelium cells are very thin, irregular in shape, and stretched out. At the bases of the folds, the cells are not clearly defined and often seem to be wanting. The cytoplasm is smooth and non-granular, while the nuclei are smaller than those of the ileum and colon, and are less chromatic. As one passes caudad, the epithelium becomes more and more glandular andcontinues out into the hypodermis of the body-wall. See Figure 18.

The basement membrane is continuous throughout the rectum as well as being continuous with the basement membrane of the body wall. In this region it is clear and well-defined.

There are several layers (usually three) of circular muscles that go around the rectum. They are striated and well-developed. These muscles are inserted on the cuticula around the proctodeal invagination. Each layer is attached independently of the other layers. There are no longitudinal muscles in the rectum of the Mexican bean beetle, neither internally nor externally.

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EXPLANATION OF THE PLATES.

All figures of adult except Fig. 7.

Plate I.

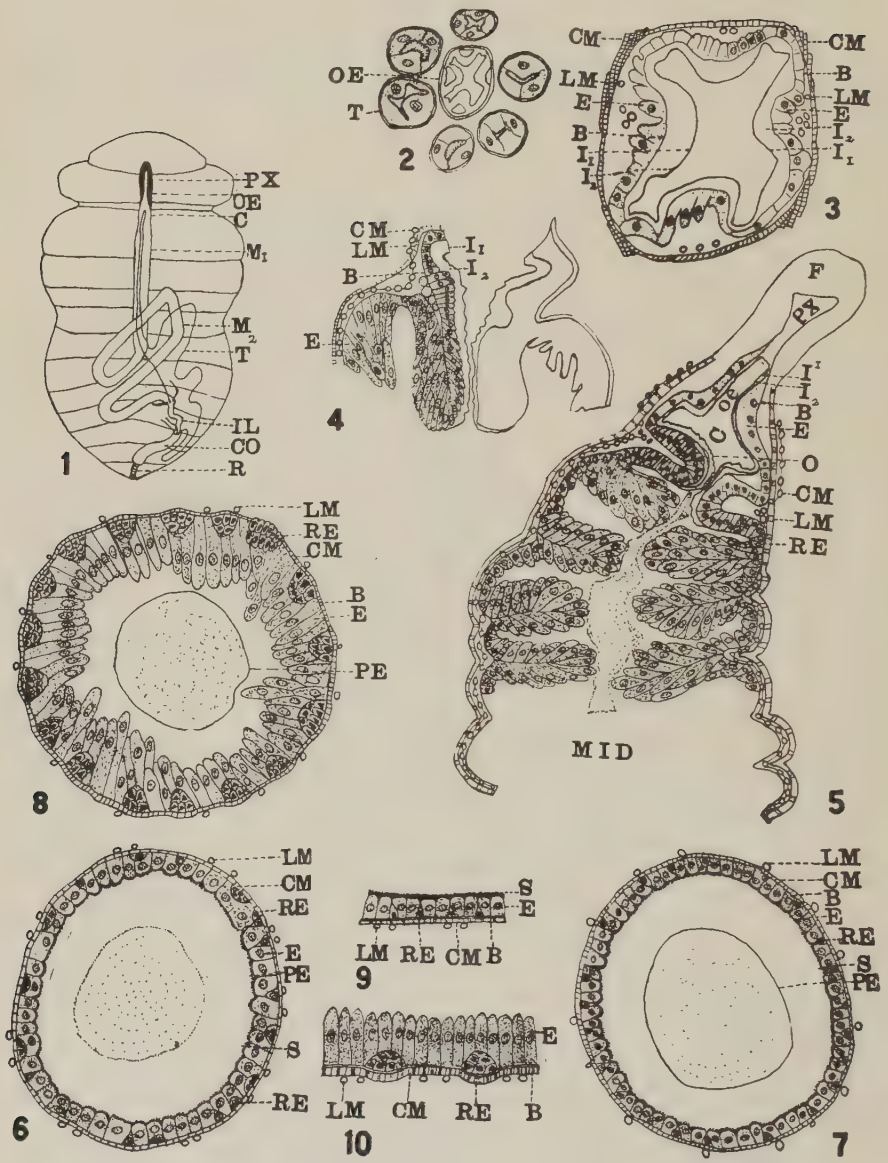
Fig. 1. The alimentary canal and malpighian tubules in the adult beetle.
Fig. 2. Cross section through the oesophagus to show its relation to the malpighian tubules.
Fig. 3. The oesophagus, cross section.
Fig. 4. The oesophageal valve, longitudinal section.
Fig. 5. The pharynx, oesophagus, crop, oesophageal valve, and the anterior portion of the first division of the mid-intestine (ventriculus), longitudinal section.
Fig. 6. The posterior portion of the first division of the ventriculus of the adult, cross section.
Fig. 7. The posterior portion of the first division of the ventriculus of the larva, cross section. Compare difference in replacement cells with Fig. 6.
Fig. 8. The second division of the ventriculus, cross section.
Fig. 9. The posterior portion of the first division of the ventriculus, cross section.

Plate II.

Fig. 10. The second division of the ventriculus, cross section.
Fig. 11. The transition from the ventriculus to the ileum, longitudinal section.
Fig. 12. A cross section, made slightly at an angle, through the invagination of the malpighian tubules showing ventriculus epithelium on the left and the ileum epithelium on the right.
Fig. 13. The origin of the malpighian tubules, cross section made a few micra behind Fig. 12.
Fig. 14. Cross section through the ileum near the transition immediately behind Fig. 13.
Fig. 15. The posterior portion of the ileum taken a few micra behind Fig. 14. cross section.
Fig. 16. The central and posterior ileum, cross section.
Fig. 17. The colon; a cross section, showing the peritoneal sheath and malpighian tubules in their relation to the colon.
Fig. 18. The rectum, a cross section.
Fig. 19. Diagram showing the ramification of the malpighian vessels in the wall of the colon.
Fig. 20. A malpighian tubule greatly enlarged.

ABBREVIATIONS USED IN THE FIGURES.

B—Basement Membrane.
C—Crop.
CO—Colon.
E—Epithelium.
HI—Hind-Intestine.
LM—Longitudinal Muscle.
MID—Mid-Intestine.
M2—Mid-Intestine (second division).
OE—Oesophagus.
ORT—Origin Mal Tubules.
Pe—Peritrophic Membrane.
R—Rectum.
S—Striated Border.
CM—Circular Muscles.
CT—Connective Tissue.
F—Fore-Intestine.
IL—Ileum.
I—Primary Intima.
I2—Secondary Intima.
M—Muscle.
M1—Mid-Intestine (First division).
O—Oesophageal Valve.
P—Peritoneum.
PX—Pharynx.
RE—Replacement Cells.
T—Malpighian tubules.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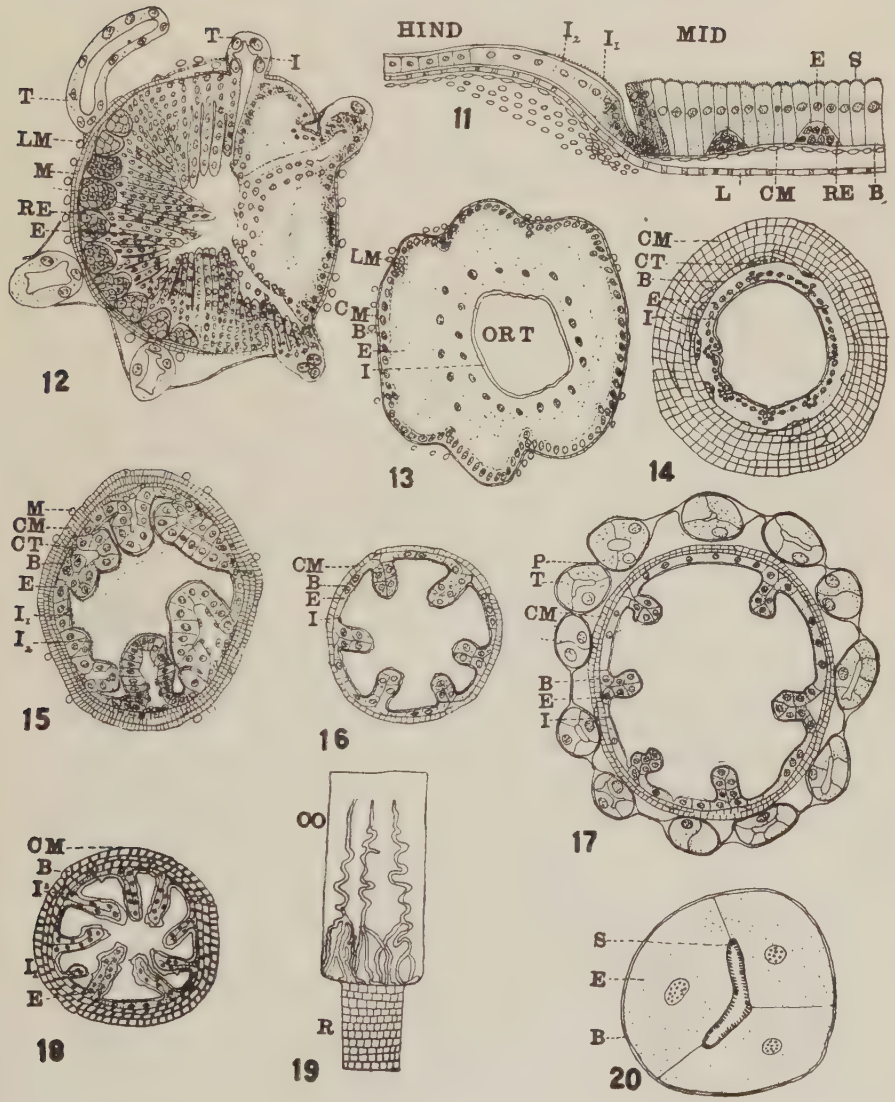
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A PHAENOLOGICAL NOTE ON THE FLORA OF THE VICINITY OF COLD SPRING HARBOR, N. Y.*

N. M. GRIER,
Dartmouth College,

AND

S. A. GREEN,
Maryville College.

In recent years interest in phaenological studies has been stimulated by the work of Sir Francis Darwin. In the first of of these studies of his on the British Flora, Darwin[1] could not correlate the first flowering of 231 species of these plants with the temperature factor. His observations in this case extended over the years 1917-18-19, and for the months of January to July inclusive of those years. In his next paper[2] he states, however, that the early flowering of the species in the years 1918 and 1920 must be connected with the relatively higher temperatures ruling in the spring of those two years. This paper gave observations upon 272 species over the period January to September during the years 1919-20. In a third paper,[3] Darwin remarks that it was not surprising for the flowering dates to be early in 1921, since the temperature had been above normal that year. Commenting upon his results from 233 species over the period November 1920 to September 1921, he observes that the rainfall during the period considered had been the smallest of the past 105 years in the British Isles. He remarks, "the connection of low rainfall with early flowering is probably to be ascribed partly to the quicker warming up of the dryer soil in the spring so that early growth would be promoted through the higher soil temperature, provided sufficient water is present for the needs of growth. In regard to early flowering as such it is well known that individual plants

*Paper on program of the Ecological Society of America, Washington meeting, 1924.

[1]1919. Darwin, Sir Francis. A Phaenological Study. New Phytologist 18:287-298.

[2]1921. *Ibid.* Studies on Phaenology, No. 2, 1920. New Phytologist 20:30-38.

[3]1922. *Ibid.* Studies on Phaenology, No. 3, 1921. New Phytologist 21:34-40.

growing in spots where the supply of water is soon exhausted produce a smaller bulk of vegetation and flower correspondingly earlier though of course less profusely than those growing in spots where water is available for a longer period."

Lyon[4] studied floral and meteorological records of the Hanover, N. H. district for the years 1917-21 inclusive. For the first and last years he was able to very definitely associate a cool temperature with late flowering while the remaining years also gave evidence in favor of the factor of temperature control on the flowering of plants. He made no attempt, however, to correlate these periods with the amount of precipitation which had occurred.

The records upon which our observations are based were made at the Biologocal Laboratory, Cold Spring Harbor, N. Y. in the summers of 1922-23-24 during the six weeks period in which the Laboratory was in session, between the last week of June and the second week in August. Many of the plants which bloom during the summer in that region may flower in the spring months, so for the purposes of accuracy we include in our observations only those species listed in Britton and Brown or Gray as blooming from June onward (Table I). Since in other cases our records were for only two of the three years considered, we have been forced to use as the basis of our tentative conclusions a comparatively small number of species—44 in all. In comparison, the number of species considered by Darwin over the same period in three years were 59, 51 and 50. The meteorological records used are those of the United States Weather Bureau Station at Roslyn, L. I., (Table II), which is comparatively near Cold Spring Harbor. While our results indicate that for each of these three years the majority of the flowers appeared in the weeks of July 8, 14 and 20, certain differences in the sequence apparently confirm the findings of Darwin and Lyon.

1922. If we compare the totals of the first four and the last three weeks of the observation period of this year with similar periods in 1923, we observe that certain species flowered later in 1922 than 1923. This was also the case in a number of other species not included in the list, because we obtained no records for them in 1924. It will be noticed from the accompanying table that 1922 was not nearly so warm as 1923 during the flowering period which fact brings out a slight correlation of

[4]1922. Lyon, C. J. A Phaenological Study in New England. Torreya 22:19-28.

time of flowering with the temperature. Although the temperatures of 1922 were largely above normal from January on, a greater number of subnormal temperatures as well as a

TABLE I.

Species	Earliest Date. Month Day†	June	July				August		
		27	8	14	20	26	1	7	13
1. Hemerocallis fulva	6–28	0	x*						
2. Lysimachia terrestris	6–28	x	0	*					
3. Rubus odoratus	6–30	x	*	0					
4. Leonurus Cardiaca	7–2		0	*		x			
5. Spartina glabra	7–2		0 x			*			
6. Spartina patens	7–2		0 x	*					
7. Verbascum Thapsus	7–3	0 *	x						
8. Agrimonia gryposepala	7–4		x	* 0					
9. Agrostis alba	7–4		* 0	x					
10. Arctium minus	7–4		*			x 0			
11. Asclepius syriaca	7–4		* 0 x						
12. Chrysopsis falcata	7–4		0 x		*				
13. Hypericum perforatum	7–4		x 0		*				
14. Lathyrus maritimus	7–4		* 0	x					
15. Melilotus alba	7–4		* 0 x						
16. Plantago maritima	7–4		0	*	x				
17. Rumex crispus	7–4		* 0		x				
18. Helianthus annuus	7–5		x	0	*				
19. Limonium carolinianum	7–5		x *	0					
20. Typha angustifolia	7–5		x	*		0			
21. Verbascum Blattaria	7–5		0 *	x					
22. Chimaphila maculata	7–6		x	0	*				
23. Circaea lutetiana	7–6		x	0	*				
24. Ligustrum vulgare	7–6		0	*	x				
25. Sericocarpus asteroides	7–6		x	0	*				
26. Linaria Cymbalaria	7–8		*	0	x				
27. Clethra alnifolia	7–9		0		x	*			
28. Nepeta Cataria	7–9		0	x	*				
29. Calluna vulgaris	7–10		*		0 x				
30. Impatiens biflora	7–10		*	x	0				
31. Cephalanthus occidentalis	7–11			x	0			*	
32. Sericocarpus linifolius	7–11			x	* 0				
33. Polygala polygama	7–11			x 0	*				
34. Amaranthus retroflexus	7–12			0			x	*	
35. Chenopodium album	7–12			0 x	*				
36. Oenothera muricata	7–12			*	0 x				
37. Verbena urticaefolia	7–12			x 0		*			
38. Mollugo verticillata	7–14			x	*	0			
39. Epipactis pubescens	7–15			x		*		0	
40. Centaurea Cyanus	7–17				0			x *	
41. Epilobium angustifolium	7–17			0	*	x			
42. Hypopitys americana	7–17			x	* 0				
43. Apocynum cannabinum	7–21				0 *	x			
44. Lobelia cardinalis	7–23				0	x	*		

†—x = 1922.
0 = 1923.
* = 1924.

TABLE II.

Roslyn, N. Y.

WEEK OR MONTH	NORMAL DAILY MEAN TEMPERATURE	DEVIATION FROM NORMAL DAILY MEAN TEMPERATURE		
		1922	1923	1924
	(1914–1924)			
January	29.48	— .69	+ .17	+1.11
February	28.88	+4.32	—3.48	—1.88
March	37.80	+3.30	—1.80	—1.40
April	48.19	+1.41	— .21	—1.90
May	58.50	+4.20	+ .30	—4.10
Total	.....	+12.54	—5.02	—8.17
	(1922, 1923, 1924)			
June 1–26	68.5	+ .9	+3.3	—4.2
June 27–July 8	69.7	+1.8	—1.0	— .9
July 9–14	72.5	— .4	+ .5	— .1
July 15–20	72.6	+ .9	+2.6	—2.5
July 21–26	72.7	— .8	+ .1	+ .6
July 27–August 1	70.0	— .3	+ .1	+ .2
August 2–7	73.5	—2.0	+2.6	— .8
Total	.....	+ .1	+8.3	—8.5

Roslyn, N. Y.

WEEK OR MONTH	NORMAL DAILY MEAN PRECIPITATION	DEVIATION FROM NORMAL DAILY MEAN PRECIPITATION		
		1922	1923	1924
	(1914–1924)			
January	4.23	—2.00	+3.28	+ .13
February	3.76	— .07	— .85	+ .40
March	3.22	+1.11	+1.02	—1.47
April	3.72	+ .26	— .72	+2.69
May	3.78	+ .45	—1.93	+1.79
Total	.....	— .25	+ .80	+3.54
	(1922, 1923, 1924)			
June 1–26	.19	+ .07	— .01	— .07
June 27–July 8	.15	+ .17	— .06	— .10
July 9–14	.15	— .11	— .15	— .06
July 15–20	.08	+ .09	— .03	— .07
July 21–26	.09	— .07	— .01	— .09
July 27–August 1	.08	+ .03	+ .03	— .07
August 2–7	.11	+ .12	— .06	— .07
Total	.....	+ .30	— .29	— .53

greater amount of precipitation occurred during the flowering season. In view of Darwin's suggestion that a low rainfall is usually associated with earlier flowering through a more rapid warming up of the soil, it seems plausible that the temperature in this case were insufficient under the conditions to have such an effect. Apparently then for this year, the low temperature abundant precipitation during the growing season together and the delayed the time of flowering with the evidence favoring the precipitation as the factor tending to nullify the accumulative effects of the higher temperatures of the preceding months.

1923. Study of the records for this year by the method previously described indicates that the majority of the flowers in this year bloomed earlier than those of 1922 and 1924. During the summer of 1923 there occurred the highest temperatures of the growing seasons of the three years considered; hence we have a positive correlation with the temperature factor. The precipitation during the growing season of this year is seen to be less than that of 1922. Since the season was neither as dry nor as cold as that of 1924, we should expect earlier flowering to characterize the year. The temperatures for this year were mostly above normal from January on, while the precipitation was above normal during the first five months only. If the number of cases really supplies sufficient evidence, this correlation checks quite well with Darwin's observation that not only higher temperatures but lower rainfall also are connected with earlier flowering.

1924. A very clear tendency toward late flowering is shown in this year through comparison of the totals of the last four weeks of the three years and this is correlated with predominantly lower temperatures. But the late flowering is correlated with lower precipitation during the flowering period. If lower rainfall is usually associated with earlier flowering through rapid warming up of the soil, this apparently contradictory instance may be explained by the fact that the temperature of the 1924 season was too low to have the usual effect in warming up the soil. Apparently then, the temperature was a stronger determinant of the time of flowering for this year than the precipitation.

In conclusion, then, it is evident that the time of flowering is determined by the prevailing temperature; this, in turn, is modified by the amount of precipitation during the growing season.

DESCRIPTIONS OF FIFTEEN NEW SPECIES OF CERATOCAPSUS (HEMIPTERA, MIRIDÆ).*

HARRY H. KNIGHT
Department of Zoology and Entomology, Iowa State College

The writer has published a key in the "Hemiptera of Connecticut" (1923) to the species of *Ceratocapsus* known from the northeastern United States. Since then considerable material from the south and southwestern states has been studied with the result that several new species have been recognized. The writer is preparing a key in which it is hoped to include all the known North American species, and later to publish with figures of the male genitalia for each species. However, pressure from various students for determinations of species has made it necessary to publish descriptions and make the names available at the earliest possible moment, with the result that the present paper is offered now.

Ceratocapsus taxodii new species.

Allied to *luteus* Kngt., and runs in the couplet with that species in my key (Hem. Conn., 1923, p. 525), but is distinguished by length of antennal segment II which is slightly greater than width of vertex plus dorsal width of an eye, also by the smaller size and reddish coloration, and yellow antennæ having segment IV reddish.

♂. Length 3.2 mm., width 1.3 mm. Head: width .77 mm., vertex .26 mm. Rostrum, length 1.17 mm., reaching to middle of hind coxæ. Antennæ: segment I, length .27 mm.; II, .86 mm.; III, .51 mm.; IV, .51 mm.; all segments nearly equal in thickness, yellow, segment IV reddish. Pronotum: length .60 mm., width at base 1.08 mm.; impunctate, alutaceous like the hemelytra. General body form very similar to *luteus*; coloration nearly uniformly reddish, in dark specimens becoming dark reddish due to a slight infuscation of the chitin; legs and antennæ uniformly yellowish except segment IV which is reddish. Pubescence very similar to that of *luteus*, although the simple pubescence somewhat more prominent. Membrane uniformly pale fuscous, becoming gradually paler toward base. Genitalia distinctive, form near that of *luteus* but the right clasper with apical third decurved and flattened at apex to a chisel-like edge.

*Contribution from the Department of Zoology and Entomology, Iowa State College, Ames, Iowa.

♀. Length 3.1 mm., width 1.3 mm. Head Width .68 mm., vertex .31 mm. Antennæ: segment I, length .27 mm.; II, .86 mm.; III, .51 mm.; IV, .51 mm. Pronotum: length .60 mm., width at base 1.08 mm. Very similar to the male in pubescence and coloration.

Holotype: ♂, June 16, 1927, Colyell, Louisiana (H. H. Knight); author's collection.

Allotype: Same data as the type.

Paratypes: 14 ♂ ♀, taken with the types on cypress (*Taxodium distichum*). FLORIDA— ♂ ♀, June 1, Sanford; 10 ♂ ♀, July 23, 1926, Jacksonville, (E. D. Ball). ILLINOIS— ♂, June 28, 1909, Pulaski (C. A. Hart), in cypress swamp. LOUISIANA— 12 ♂ ♀, June 15, Bogalousa; ♂, June 15, Covington; 2 ♂ 2 ♀, June 18, 1917, Shriever (H. H. Knight). MISSISSIPPI—6 ♂ ♀, July 24, Columbus; ♂ 2 ♀, July 15, Durant; ♀, July 23, Natchez; ♂ 2 ♀, July 22, Port Gibson; 2 ♀, June 18, Vicksburg (C. J. Drake). TENNESSEE—18 ♂ ♀, July 16, 1919, Walnut log (W. L. McAtee), on cypress.

Ceratocapsus bifurcus new species.

Allied to *lutescens* Reut., and very similar in coloration, but differs in the more prominent, bristly pubescence, vertex broadly but distinctly concave, and by the very distinct genital claspers.

♂. Length 4.1 mm., width 1.8 mm. Head: width .91 mm., vertex .30 mm.; eyes more prominent above than in *lutescens*, being emphasized by the shallowly concave vertex. Rostrum, length 1.43 mm., attaining hind margins of intermediate coxæ. Antennæ: segment I, length .37 mm.; II, 1.28 mm.; III, .63 mm.; IV, missing. Pronotum: length .74 mm., width at base 1.4 mm.

Coloration nearly identical with *lutescens;* uniformly pale yellowish, head and two lines above base of coxal cleft bright red. Genital claspers distinctive; left clasper with basal, dorsally projecting process, bifurcate on apical half and curving distad, the dorsal prong more slender and curving inward. Right clasper very different from *lutescens* and *rubricornis*, being more nearly the form of *modestus* Uhl., but the apical half decurved, thick, and ending in an abrupt sharp point.

♀. Length 4 mm., width 1.9 mm. Head: width .86 mm., vertex .37 mm. Antennæ: segment I, length .37 mm.; II, 1.33 mm.; III, .60 mm.; IV, .56 mm. Pronotum: length .78 mm., width at base 1.46 mm. Similar to the male in coloration and pubescence.

Holotype: ♂, April 2, 1921, Miami, Florida (D. M. DeLong); author's collection.

Allotype: May 5, 1926, Cocoa, Florida (E. D. Ball); author's collection.

Paratype: ♀, June 14, 1921, Miami, Florida (D. M. DeLong). ♀, April 20, 1912, Marco, Florida (W. T. Davis). 2 ♂ 4 ♀, July 23, 1926, Jacksonville (E. D. Ball).

Ceratocapsus rubricornis new species.

Allied to *lutescens* Reut., and very similar in coloration, but distinguished by the genital claspers and the uniformly red antennæ.

♂. Length 4.3 mm., width 1.7 mm. Head: width .87 mm., vertex .31 mm. Rostrum, length 1.4 mm., reaching upon base of hind coxæ. Antennæ: segment I, length .47 mm.; II, 1.5 mm., equal in thickness to segment I, although more slender basally; III, .77 mm.; IV, .70 mm.; deep red, last two segments somewhat darker red. Pronotum: length .86 mm., width at base 1.4 mm.; relatively longer than in *lutescens*.

Coloration and pubescence nearly as in *lutescens*, but differs in the uniformly red antennæ; uniformly yellowish, head, propleura above middle of coxal cleft, and hind tibiæ, bright red. Genital claspers distinctive; differs from *lutesens* by the long decurved, sickle-shaped apical half of right clasper, and the broader basal spine.

♀. Length 4.4 mm., width 1.9 mm. Head: width .81 mm., vertex .37 mm. Antennæ: segment I, length .47 mm.; II, 1.63 mm.; III, broken. Pronotum: length .80 mm., width at base 1.43 mm. Coloration and pubescence similar to the male.

Holotype: ♂, June 22, 1921, Agricultural College, Mississippi (C. J. Drake); author's collection.

Allotype: Same date as the type.

Paratype: ♂, taken with the type.

Ceratocapsus divaricatus new species.

This species runs to *incisus* Kngt. in my key (Hem. Conn., 1923, p. 525), but differs in the sparsely set, erect long hairs on hemelytra, in the larger and more prominent eyes, and the more strongly infuscated membrane.

♂. Length 3.3 mm., width 1.2 mm. Head: width .78 mm., vertex .25 mm. Rostrum, length 1.03 mm., scarcely attaining posterior margins of intermediate coxæ. Antennæ: segment I, length .23 mm., brown, a red annulus at base; II, .73 mm., gradually thickened from base toward apex where it attains the thickness of segment I, dark fuscous brown, more reddish brown at apex; III, .41 mm., scarcely attaining the thickness of segment II, brownish black; IV, missing. Pronotum: length .68 mm., width at base 1.19 mm.; finely punctate.

Brownish black to piceous, clavus and base of corium brown; coxæ apically, bases of femora, apices of tibiæ except hind pair, and tarsi, more or less pale. Membrane dark fuscous, bordering the cuneus and

more or less behind anal vein, pale with a tinge of brown. Dorsum finely punctate; rather thickly clothed with silvery, fine scale-like pubescence, and intermixed with sparsely set, erect, long brownish hairs, the arrangement very similar to that of *setosus* Reuter. Genitalia very distinctive, right clasper with a distal acuminate process (length .185 mm.), also with an incurved sickle-shaped arm arising from the thick base. Left clasper with an erect basal process, terminating in a point turned at right angles, the apical arm makes a right angle turn dorsally, producing a vertical process which terminates above in a broad spear-shaped point set at a right angle; the points on the two arms of the clasper point in opposite directions like the hands on the upraised arms of an Egyptian dancer, but the left hand or point is much larger than the other.

Holotype: ♂, May 15, 1926, Sanford, Florida (E. D. Ball); author's collection.

Ceratocapsus balli new species.

Allied to *divaricatus*, and is distinguished most easily by the differently formed male genitalia; pronotal disk impunctate. Runs to *sericus* Kngt. in my key (Hem. Conn., 1923, p. 525) but is distinguished by the shorter antennal segments, smaller and more slender form, and by the piceous and more strongly shining aspect.

♂. Length 3.4 mm., width 1.17 mm. Head: width .74 mm., vertex .257 mm. Rostrum, length 1 mm., reaching to middle of intermediate coxæ. Antennæ: segment I, length .24 mm.; II, .85 mm.; III, .46 mm.; IV, .40 mm. Pronotum: length .60 mm., width at base 1.13 mm.; disk impunctate, strongly shining, clothed with rather long simple pubescence. Hemelytra with pubescence and punctuation nearly as in *divaricatus*; apical half of corium and cuneus piceous, strongly shining. Membrane and veins pale with yellowish tinge, dark fuscous on apical half, or behind a transverse line formed by apices of areoles.

Genital claspers distinctive, although indicating a close relationship with *divaricatus*; right clasper forming a rather long, curved, U-shaped structure, the internal arm more slender, the apex bent or hooked. Left clasper with basal prong short, acuminate, suberect, the apical arm somewhat curved, non-angulate, the apex broad and flat, forming a point at each side of the flattened apical area.

♀. Length 2.9 mm., width 1.2 mm. Head: width .66 mm., vertex .30 mm. Antennæ: segment I, length .23 mm.; II, .76 mm.; III, .44 mm.; IV, .40 mm. Pronotum: length .57 mm., width at base 1.1 mm. Coloration, pubescence, and punctuation, very similar to that of the male.

Holotype: ♂, May 15, 1926, Sanford, Florida (E. D. Ball); author's collection.

Allotype: Same data as the type.

Paratypes: ♂, May 5; ♂, May 9, 1918, Gainesville, Florida (C. J. Drake). 3 ♀, June 1, 1926, Sanford, Florida (E. D. Ball), collected on live oak.

Ceratocapsus uniformis new species.

This species runs to *incisus* Kngt., in my key (Hem. Conn., 1923, p. 525), but differs in the shorter antennal segment III, which is not equal to width of vertex plus dorsal width of an eye, in the shorter and more ovate form, uniformly dark brown color, fuscous membrane, and the differently formed genital claspers.

♂. Length 3 mm., width 1.5 mm. Head: width .70 mm., vertex .27 mm. Rostrum, length 1 mm., reaching upon middle of hind coxæ. Antennæ: segment I, length .23 mm.; II, .80 mm.; III, .43 mm.; IV, .37 mm.; yellowish, segment IV brownish, and segment I with red mark at base as in *rufistigmus*. Pronotum: length .60 mm., width at base 1.26 mm.

Dorsum more sparsely clothed with yellowish simple pubescence than in *pumilus* Uhler, and intermixed with fine scale-like pubescence; punctuation slightly stronger and more distinct. Coloration uniformly dark reddish brown, darker on anterior half of pronotum and somewhat paler on basal margin. Membrane uniformly fuscous brown. Legs yellowish, hind femora more brownish on apical half. Genital structures very suggestive of *pumilus*, but differs in the much smaller and margined tubercle above base of left clasper; the middle prong of left clasper lying flat against the large apical prong; the middle prong of the right clasper flat and blade-like.

♀. Length 3 mm., width 1.5 mm. Head: width .70 mm., vertex .31 mm. Antennæ: segment I, length .23 mm.; II, .86 mm.; III, .43 mm; IV, .37 mm. Pronotum: length .60 mm., width at base 1.28 mm. Similar to the male in punctuation, pubescence, and coloration.

Holotype: ♂, July 18, 1915, Springfield, Missouri (H. H. Knight); author's collection.

Allotype: July 22, 1915, Hollister, Missouri (H. H. Knight).

Paratypes: DISTRICT OF COLUMBIA— ♂ ♀, July 30, Aug. 18, 1907; Washington (W. L. McAtee). ILLINOIS— ♂, July 20, 1909, Fountain Bluff. MARYLAND— ♀, Aug. 14, Beltsville; ♂, July 12, Odenton; ♀, July 19, ♀, Aug. 2, 1914, Plummers Island (W. L. McAtee); ♀, July 9, 1905, Marshall Hall (J. G. Sanders). MISSISSIPPI— ♀, July 24, Columbus; ♀, July 9, 1921, Corinth (C. J. Drake). VIRGINIA—6 ♀, July 27, 1898, Paris (O. Heidemann); ♂, Aug. 1, 1915, Mount Vernon (W. L. McAtee). WEST VIRGINIA—2 ♀, Aug. 20, 1891, Berkeley (O. Heidemann).

Ceratocapsus quadrispiculus new species.

Allied to *uniformis* and very similar in size and coloration, but differs in the strongly arcuate embolar margins and very distinct genital characters; rostrum somewhat shorter, membrane uniformly dusky, legs uniformly yellowish.

♂. Length 2.9 mm., width 1.5 mm. Head: width .68 mm., vertex .31 mm. Rostrum, length 1.04 mm., not attaining hind margins of middle coxæ. Antennæ: segment I, length .24 mm.; II, .81 mm.; III, .42 mm.; IV, .32 mm.; yellowish, segment IV reddish, segment I, with red mark near base. Pronotum: length .58 mm., width at base 1.2 mm.

Coloration very similar to *uniformis* but the dorsum more densely clothed with pubescence. Membrane uniformly dusky, paler than in *uniformis*. Legs yellowish. Genital structures distinctive; left clasper with four prongs, the middle pair having a common base, curving upward and U-shaped; right clasper with basal prong short, flat, the broad apex curving slightly upward to a point, the apical prong recurved above, rather broad and flattened at apex, and nearly reaching base of clasper, also having a short, curved subapical prong.

Holotype: ♂, June 16, 1917, Colyell, Louisiana (H. H. Knight); author's collection.

Paratypes: 2♂, taken with the type. ♂, July 23, 1922, Glen Echo, Maryland (J. R. Malloch).

Ceratocapsus complicatus new species.

Suggestive of *pumilus* Uhler, but having long erect simple pubescence on the dorsum as in *setuosus* Reut., runs to *pumilus* in my key (Hem. Conn., 1923, p. 525) but distinguished at once by the long erect pubescence; usually two fuscous spots are visible on pronotal disk, one behind each callus.

♂. Length 3.8 mm., width 1.5 mm. Head: width .77 mm., vertex .257 mm. Rostrum, length 1.16 mm., just attaining hind margins of middle coxæ. Antennæ: segment I, length .27 mm., yellowish, with red mark near base; II, 1 mm., yellowish; III, .57 mm., reddish brown; IV, .47 mm., dark reddish. Pronotum: length .68 mm., width at base 1.26 mm.

Coloration and punctuation nearly as in *pumilus*, but pubescence nearly as in *setosus*. Genital structures very distinctive; right clasper with basal fork directed downward where it divides into two sickle-shaped blades which recurve inwardly, the dorsal half of clasper with a pair of shorter, U-shaped prongs above, the posterior fork twice as long as the other; left clasper shaped like the tail of a fish apically, with a short spine above near base; the chitinous terminal portion of the aedeagus divided into a pair of ventrally curved blades.

Holotype: ♂, July 22, 1915, Hollister, Missouri (H. H. Knight); author's collection.

Paratypes: ♂, May 19, July 4, 1918, Gainesville, Florida (C. J. Drake). ♂, July 24, 1921, Columbus, Mississippi (C. J. Drake). 2♂, Aug. 9, 1913, Plum Point; ♂, Aug. 14, 1914, Beltsville, Maryland (W. L. McAtee).

Ceratocapsus fuscosignatus new species.

Suggestive of *punctulatus* Reuter described from Texas, but differs in the shorter pubescence, shorter antennal segments, and the setigerous punctures of the dorsum not infuscated.

♂. Length 2.7 mm., width .97 mm. Head: width .67 mm., vertex .214 mm. Rostrum, length 1.03 mm., extending upon middle of hind coxæ. Antennæ: segment I, length .26 mm.; II, .91 mm., not equal to one and a half times width of head; III, .63 mm., nearly equal to width of head; IV, .38 mm.; yellowish, last segment dusky. Pronotum length .44 mm., width at base .88 mm.

Dorsum more finely and closely punctate than in *punctulatus* but the punctures not infuscated. Clothed with fine golden yellow simple pubescence and intermixed with fine scale-like silvery pubescence, the whole interspersed with a series of erect, longer golden yellow hairs, much as in *setosus* Reut., but shorter than those on *punctulatus*. Coloration rather uniformly yellowish, cuneus and sometimes the corium tinged with reddish, scutellum and inner apical angles of corium usually infuscated, hind tibiæ and head sometimes becoming infuscated. Membrane fuscous, pale within areoles and bordering apex of cuneus. Genital claspers distinctive, the right clasper with claw-like hook above base while the apical process terminates in a hook of equal size and form.

♀. Length 2.6 mm., width 1.03 mm. Head: width .61 mm., vertex .28 mm. Antennæ: segment I, length .21 mm.; II, .86 mm.; III, .60 mm.; IV, .40 mm. Pronotum: length .44 mm., width at base .83 mm.; III, .60 mm.; IV, .40 mm. Very similar to the male in punctuation, pubescence and coloration.

♀. Brachypterous form. Length 2.2 mm., width 1 mm. Head: width .64 mm., vertex .28 mm. Rostrum, length 1.14 mm., extending behind posterior coxæ or to base of ovipositor. Antennæ: segment I, length .26 mm.; II, .88 mm; III, .56 mm.; IV, .46 mm. Pronotum: length .43 mm., width at base .76 mm. Hemelytra rounded at apex, cuneal fracture distinct, membrane reduced to a narrow margin bordering inner side of cuneus, last segment of abdomen and tip of ovipositor exposed above. Punctuation, pubescence, and coloration similar to the macropterous form.

Holotype: ♂, October, 1925, Tampa, Florida (E. D. Ball); author's collection.

Allotype: Same data as the type.

Paratypes: ALABAMA—36 ♂ ♀, September 5 and 6, Eufaula; ♀, September 8, 1926, Clanton, at light (H. H. Knight). ARIZONA—3 ♀, July 20, 1917, Texas Pass; ♀, July 22, 1917,

Tucson (H. H. Knight). ARKANSAS—♂, September 10, 1926, Newark, at light (H. H. Knight). FLORIDA—♂ ♀, May 3, 1916, Cocoa; ♀, May 15, 1926, ♂, August 25, 1925, Sanford (E. D. Ball); ♂, April 16, 1914, Orlando (G. G. Ainslie). IOWA—♂, May 8, 1926, Ames (H. H. Knight), collected at light. NEW MEXICO—♂, July 12, 1917, Deming (H. H. Knight), at light. TEXAS—3 ♀, August 30, Brownwood; ♂, June 26, Gillette; 3 ♂, June 23, Richmond; 2 ♂, July 2, Sabinal; 2 ♂ 1 ♀, June 25, 1917, Victoria (H. H. Knight).

Morphotype: ♀, August 25, 1925, Sanford, Florida (E. D. Ball); author's collection.

Paramorphotypes: ♀, July 12, 1917, Tucson, Arizona (H. H. Knight). 3 ♀, May 5, 1926, Cocoa, Florida (E. D. Ball); ♀, July 1, 1917, Helotes, Texas (H. H. Knight).

Ceratocapsus barbatus new species.

Runs to *modestus* Uhler in my key (Hem. Conn., 1923, p. 525), but is distinguished by the more prominent and thickly set, suberect pubescence, the eyes also distinctly pubescent.

♂. Length 4.2 mm., width 1.8 mm. Head: width .86 mm., vertex .32 mm.; eyes and head clothed with prominent erect pubescence. Rostrum, length 1.5 mm., reaching to middle of hind coxæ. Antennæ: segment I, length .38 mm.; II, 1.33 mm., somewhat more slender than segment I; III, .59 mm., equal to thickness of segment II; IV, .50 mm., equal to thickness of segment III; uniformly dark brown, clothed with prominent pubescence. Pronotum: length .80 mm., width at base 1.42 mm.; impunctate.

Clothed with prominent, erect or suberect, simple brown pubescence. Coloration uniformly dark brown, the pronotum and scutellum darker brown, sometimes nearly piceous, apex of scutellum reddish; antennæ and legs usually of a lighter shade of brown. Genital claspers distinctive although closely related to *modestus* Uhler; apical half of left clasper with the two arms widely divergent.

♀. Length 4.4 mm., width 1.8 mm. Head: width .83 mm., vertex .38 mm. Antennæ: segment I, length .37 mm.; II, 1.33 mm.; III, .56 mm.; IV, .44 mm. Pronotum: length .80 mm., width at base 1.45 mm. Pubescence and coloration similar to the male.

Holotype: ♂, July 11, 1926, Vienna, Virginia (H. H. Knight); author's collection.

Allotype: Same data as the type.

Paratypes: 2 ♂, taken with the types on *Pinus virginiana* to which tree the species appears to be confined in its breeding habits. DISTRICT OF COLUMBIA—16 ♂ ♀, June 24, ♂, July 16, 1897; ♀, July 12; ♂, July 25, 1909, Washington (O. Heide-

mann). MARYLAND—2 ♂ ♀, July 20, 1892, Bladensburg (O. Heidemann). ♂ ♀, June 14, 1914; ♀, August 8, 1915, Beltsville; ♂ 3 ♀, July 25, 1914, Great Falls; ♀, June 17, 1913, Plummers Island (W. L. McAtee), on *Pinus virginiana*. ♀, July 17; ♂, July 25, 1926, Glen Echo (H. H. Knight), on *Pinus virginiana*.

Ceratocapsus mcateei new species.

Runs to *lutescens* Reut. in my key (Hem. Conn., 1923, p. 525), but differs in the small size, brownish head and pronotum, and by the red hind femora and cuneus; clothed with fine, short, simple pubescence.

♀. Length 2.8 mm., width 1.3 mm. Head: width .64 mm., vertex .29 mm.; brown, lower face more yellowish. Rostrum, length 1.06 mm., reaching upon hind coxæ, yellowish, apex blackish. Antennæ: segment I, length .25 mm., pale yellowish, a red mark at base; II, .95 mm., gradually thickened apically, where it equals thickness (.089 mm.) of segment I, pale, uniformly pale yellowish; III, .53 mm., equal to thickness of segment II, yellowish, apical half reddish; IV, .38 mm., equal to thickness of segment III, reddish. Pronotum: length .53 mm., width at base 1 mm.; impunctate, brown to dark brown, a tinge of red sometimes apparent. Scutellum impunctate, yellowish to dusky; sternum yellowish brown, reddish brown on pleura.

Clothed with fine, short, simple, pale pubescence. Hemelytra pale yellowish, inner apical angles of corium pale fuscous; cuneus red to brownish,apex and outer margin more yellowish. Legs uniformly pale yellowish, hind femora reddish except on base. Venter uniformly yellowish, reddish brown on sides at base.

Holotype: ♀, October 11, 1914, Laurel, Maryland (W. L. McAtee); collection of W. L. McAtee.

Paratypes: ♀, taken with type. ♀, July 12, 1914, Odenton, Maryland (J. D. Hood).

Ceratocapsus downesi new species.

Runs to *pumilus* Uhler in my key (Hem. Conn., 1923, p. 525), but differs in the more slender form and brownish black color, shorter antennal segment II, narrower vertex, and very different male genitalia.

♂. Length, 4.3 mm., width, 1.5 mm. Head: width, .80 mm., vertex .23 mm. Rostrum, (imbedded) probably reaching upon hind coxæ. Antennæ: segment I, length, .27 mm.; II, .97 mm.; III, .58 mm.; IV, .51 mm. Pronotum: length, .62 mm., width at base, 1.28 mm.

Dorsum rather closely and uniformly punctured as in *pumilus*; pubescence very similar to *pumilus*. General coloration brownish black,

hemelytra somewhat translucent so that the punctures appear darker, cuneus blackish with a trace of red in hypodermis; legs pale to brownish black. Membrane pale fuscous, apical half and veins somewhat darker. Genital segment and claspers much more reduced than in *pumilus;* right clasper reduced to a minute rounded knob. but supporting three or four long hairs; left clasper with only two small slender prongs.

Holotype: ♂, July 30, 1922, Saanich District, British Columbia (W. Downes); Canadian National collection.

Paratypes: ♂, Sept. 6; ♂, Sept. 11; ♂, Sept. 14, 1918, Saanich District, B. C. (W. Downes); ♂, Sept. 14, Victoria, B. C. (W. Downes).

Ceratocapsus biformis new species.

Allied to *drakei* Kngt., but distinguished by the dark color, relatively shorter antennal segments, red head and legs, and in structure of the male genital claspers.

♂. Length, 4.9 mm., width, 1.6 mm. Head: width, .74 mm., vertex .28 mm. Rostrum, length, 1.4 mm., reaching upon middle of the hind coxæ. Antennæ: segment I, length, .40 mm., yellowish red; II, 1.4 mm., yellowish brown, becoming brownish black on apical half; III, .84 mm., blackish; IV, .54 mm., black. Pronotum: length, .60 mm., width at base, 1.23 mm.

Punctuation and pubescence nearly as in *drakei.* Color brownish black to black, head, cuneus, and legs bright red, legs sometimes paler, especially on coxæ and bases of femora. Membrane dark fuscous, somewhat paler transversely across apical half of areoles. Genital claspers having the same general form of *drakei,* but right clasper with shorter and more strongly recurved dorsal prong, while the lower prong follows the wall of the genital segment for half its length then turns sharply upward, the bend of the elbow produced into a spear-shaped heel.

♀. Brachypterous, length, 2.7 mm., width, 1.5 mm. Head: width, .73 mm., vertex, .34 mm. Rostrum, length, 1.33 mm., extending upon hind coxæ. Antennæ: segment I, length, .33 mm.; II, 1.03 mm.; III, .64 mm.; IV, .47 mm. Pubescence, punctuation, and coloration very similar to the male, but pronotum more reddish. Hemelytra rounded at apex, cuneus short and rounded, with only a trace of membrane present, cuneal fracture apparent.

Holotype: ♂, August 15–22, 1924, Pingree Park, Colorado (Drake & Hottes); author's collection.

Allotype: Same data as the type.

Paratypes: 6 ♂ 3 ♀, taken with the types. ARIZONA— ♀, July 27, 1917, Mt. Lemon, alt. 9000 ft., Santa Catalina Mts., (H. H. Knight); ♂ ♀, August 3, 1905, Huachuca Mts. (H. G. Barber). COLORADO—2 ♀, July 24, 1909, Golden (W. J. Gerhard); 3 ♂ 5 ♀, June 12, 1900, Fort Collins; 2 ♂ ♀, June 13, 1898, Rist

Canyon (E. D. Ball). MONTANA, ♂, September 3, 1912, Bozeman. ♂ 2 ♀ June 24, 1925, Williams, Arizona (A. A. Nichol).

This species was obtained by Drake and Hottes by sweeping grasses and sedges.

Ceratocapsus tricolor new species.

Allied to *biformis*, but distinguished by the genital claspers, black color with pale yellowish clavus and reddish femora.

♂. Length 5 mm., width 1.48 mm. Head: width .77 mm., vertex .31 mm.; eyes finely pubescent. Rostrum, length 1.4 mm., reaching to middle of hind coxæ, blackish. Antennæ: segment I, length .41 mm., yellowish, blackish on the constricted basal one-fourth; II, 1.6 mm., cylindrical, scarcely equal to thickness of segment I, black, slightly yellowish at base, finely yellowish pubescent; III, .98 mm., scarcely equal to thickness of segment II, black; IV, .68 mm., slightly more slender than III, black. Pronotum: length .59 mm., width at base 1.11 mm.; impunctate, scutellum likewise impunctate, but the hemelytra with fine setigerous punctures apparent. Ostiolar peritreme with dorsal lobe broadly convex, whereas *biformis* has a small convex area.

Clothed with long, erect, golden yellow simple pubescence; devoid of the silvery scale-like hairs found in *biformis*. Black, moderately shining, hemelytra more of a fuscous black, clavus pale yellowish translucent, embolium usually somewhat yellowish; membrane pale, apical half fuscous, femora reddish, becoming darker at base; coxæ pale, fuscous at base, front pair reddish to piceous; tibæ reddish brown to fuscous, tarsi yellowish, blackish apically. Genital claspers distinctive, right clasper with the ventral arm broadly arcuate, not sharply bent as in *biformis*, the dorsal arm flattened, bifid on apex.

Holotype: ♂, August 13, 1925, Mancos, Colorado (H. H. Knight); author's collection.

Paratypes: ♂, August 9, 1925, Veta Pass, alt. 8500 ft.; ♂, August 12, 1925, South Fork, Colorado (H. H. Knight). These specimens were swept from mixed growth of sedges in damp places, which seems to indicate the type of habitat.

Ceratocapsus fulvipennis new species.

Runs to *sericus* Kngt. in my key (Hem. Conn., 1923, p. 525), but differs in the smaller size, more abundant erect hairs, intermixed with fine, golden yellow, sericeous pubescence.

♂. Length 4 mm., width 1.48 mm. Head: width .74 mm., width of vertex at base .326 mm., narrowest point forward .281 mm.; eyes finely pubescent. Rostrum, length 1.18 mm., reaching to middle of hind coxæ. Antennæ: segment I, length .25 mm.; II, 1.06 mm., equal

in thickness (.09 mm.) to segment I, slightly more slender near base; III, .62 mm., equal in thickness to segment II; IV, .53 mm., slightly more slender than III; brownish yellow, last two segments fuscous. Pronotum: length .56 mm., width at base 1.2 mm.; impunctate although minutely rugulose, scarcely shining.

Clothed with rather abundant, long erect hairs, and intermixed with shorter simple pubescence, and fine prostrate, sericeous, golden yellow pubescence. Color yellow brown to dark brown, pronotum somewhat darker than head, scutellum more yellowish than brown; hemelytra fulvous, subtranslucent, embolium and cuneus of somewhat deeper color. Membrane uniformly fuscous, areoles somewhat paler. Legs reddish brown to dark brown, tibiæ scarcely paler; venter and sternum of the same brown color, shining.

Holotype: ♂, August 7, 1925, Stonewall, alt. 8500 ft., near Trinidad, Colorado (H. H. Knight); author's collection.

Paratype: ♂, taken with the type on pine, probably *Pinus ponderosa.*

A CHECK LIST OF THE CARABIDÆ OF COLUMBUS, OHIO, AND VICINITY.

R. T. EVERLY

This list is based on work done at the Ohio State University under the direction of Dr. Herbert Osborn. The insects listed are from the University collection, from a list of the insects of the Ohio State Campus collected by A. E. Miller, and from my own collection. The list is not complete but gives a good representation of the species common to Central Ohio. It includes 59 genera and 133 species.

CARABINÆ

1. Carabus—Linn.
   - limbatus—Say.
   - vinctus—Web.
2. Calosoma—Web.
   - externum—Say.
   - scrutator—Fab.
   - wilcoxi—Lec.
   - calidum—Fab.
3. Elaphrus—Fab.
   - ruscarius—Say.
4. Notiophilus—Dum.
   - semistriatus—Say.
   - (sibiricus—Cr.)
5. Nebria—Latr.
   - pallipes—Say.
6. Scarites—Fab.
   - subterraneous—Fab.
   - substriatus—Hald.
7. Dyschirus—Bon.
   - globulosis—Say.
   - haemorhoidalis—Dej.
8. Clivina—Latr.
   - impressifrons—Lec.
   - punctigera—Lec.
   - pipustulata—Fab.
9. Ardistomus—Putz.
   - viridis—Say.

HARPALINÆ

10. Panagaeus—Latr.
    - fasciatus—Say.
11. Bembidion—Latr.
    - inaequale—Say.
    - confusum—Hayw.
    - laevigatum—Say.
    - planum—Hald.
    - chalceum—Dej.
    - patruele—Dej.
    - intermedium—Kby.
    - dorsale—Say.
    - variegatum—Say.
    - affine—Say.
    - impotens—Csy.
    - (pictus—Lec.)
    - decipiens—Dej.
    - quadrimaculatum—Linn.
12. Patrobus—Dej.
    - longicornis—Say.
13. Pterostichus—Bon.
    - *femoralis—Kby.
    - *hamiltoni—Horn.
    - *patruellis—Dej.
    - *sayi—Brulle.
14. Gastrellarius—Csy.
    - honestus—Say.
15. Eumolops—Csy.
    - furtiva—Lec.
    - sodalis—Lec.
16. Evarthrus—Lec.
    - orbatus—Newm.
17. Euferonica—Csy.
    - stygica—Say.
    - coracina—Newm.
18. Abacidus—Lec.
    - permundus—Say.
19. Poecilus—Bon.
    - chalcites—Say.
    - lucublandus—Say.
20. Dysidius—Chaud.
    - mutus—Say.
21. Stereocerus—Kby.
    - heamatopus—Dej.
22. Dradytus—Steph.
    - scharwzi—Hayw.
23. Amara—Bon.
    - fallax—Lec.
    - cupreolata—Putz.
    - *exarata—Dej.

*Not listed in Leng's check list, but is in Henshaw's.

24. Triaena—Lec.
    angustata—Say.
25. Rembus—Latr.
    (Diplocheila—Brulle.)
    laticollis—Lec.
26. Dicaelus—Bon.
    dilatus—Say.
    purpuratus—Bon.
    sculptilis—Say.
    elongatus—Bon.
    teter—Bon.
27. Badister—Clairv.
    notatus—Hald.
28. Calathus—Bon.
    gregarious—Dej.
29. Platynus—Bon.
    hypolithus—Say.
    sinuatus—Dej.
    brunneomarginatus—Mann.
    extensicollis—Say.
    var. viridis—Lec.
    decorus—Say.
    affinis—Kby.
    cupripennis—Say.
    excavatus—Dej.
    ferreus—Hald.
    nutans—Say.
    octopunctatus—Fab.
    placidus—Say.
    bembidioides—Kby.
    rubripes—Lec.
    punctiformis—Say.
30. Atranus—Lec.
    pubescens—Dej.
31. Casnonia—Latr.
    pennsylvanica—Linn.
32. Leptotrachelus—Latr.
    dorsalis—Fab.
33. Galerita—Fab.
    janus—Fab.
    bicolor—Drury.
34. Lebia—Latr.
    grandis—Hentz.
    atriventris—Say.
    viridis—Say.
    ornata—Say.
    analis—Dej.
    scalpularis—Dej.
35. Calleida—Dej.
    punctata—Lec.
36. Pinacodera—Schaum.
    limbata—Dej.
37. Blechrus—Motsch.
    glabratus—Duft.
    (nigrinus—Mann.)
38. Helluomorpha—Lap.
    bicolor—Harris.
39. Cymindis—Latr.
    pilosa—Say.
40. Brachinus—Web.
    americanus—Lec.
    viridipennis—Dej.
    var. perplexus—Dej.
    conformis—Dej.
41. Chlaenius—Bon.
    tomentosus—Say.
    impunctifrons—Say.
    pennsylvanicus—Say.
    brevilabris—Lec.
    tricolor—Dej.
    nemoralis—Say.
    leucocelis—Chev.
    aestivus—Say.
    diffinis—Chd.
    sericeus—Forst.
42. Anomoglossus—Chd.
    pussilus—Say.
43. Geopinus—Lec.
    incrassatus—Dej.
44. Cratacanthus—Dej.
    dubius—Beauv.
45. Harpalus—Latr.
    calaginosus—Fab.
    compar—Lec.
    pennsylvanicus—DeG.
    (faunus—Lec.)
    herbivagus—Say.
46. Gynandrus—Dej.
    hylacis—Say.
47. Triplectus—Lec.
    rusticus—Say.
48. Anisodactylis—Dej.
    harrisii—Lec.
    nigerrimus—Dej.
    melanopus—Hald.
    (agricola—Lec.)
49. Amphasia—Newn.
    interstitalis—Say.
50. Pseudamphasia—Csy.
    sericeus—Harris.
51. Anadaptus—Csy.
    discoideus—Dej.
    baltimorensis—Say.
52. Anisotarsus—Chd.
    terminatus—Say.
53. Triliarthrus—Csy.
    artimedius—Say.
54. Stenocellus—Csy.
    ruprestris—Say.
55. Goniolophus—Csy.
    rectangulus—Chd.
56. Acupalpus—Latr.
    carus—Lec.
57. Stenolophus—Dej.
    ochropezus—Say.
    fulginosus—Dej.
    conjunctus—Say.
58. Tachistodes—Csy.
    partiarius—Say.
59. Agonderus—Dej.
    lineola—Fab.
    pallipes—Fab.

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